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ABSTRACT

This publication documents the testimony and discussion before the United States House of Representatives' Task Force on Science Policy during three days in 1985. It includes the text of the prepared statements by: (1) Dr. Bernadine Healy (Office of Science and Technology Policy, Executive Office of the President); (2) Henry G. Kirschenmann, Jr. (U.S. Department of Health and Human Services); (3) Dr. Dale R. Corson (Cornell University); (4) Dr. T. Edward Hollander (New Jersey State Department of Higher Education); (5) Dr. Oliver D. Hensley (Texas Tech University); (6) Hayden W. Smith (Council for Financial Aid to Education, New York); (7) Dr. Frank B. Sprow (Exxon Research & Engineering Co.); (8) Dr. Donald N. Langenberg (University of Illinois at Chicago); (9) Dr. Richard A. Zdanis (The Johns Hopkins University); (10) Dr. Ray C. Hunt, Jr. (business and finance, Charlottesville, Virginia); and (11) Dr. Praveen Chaudari (IBM Corp.). The appendices contain copies of other papers submitted to the task force which pertained to such topics as voluntary support of education, university laboratory needs, financing and managing university research equipment, and research facilities and equipment. (TW)

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Science Policy Study—Hearings Volume 6
THE FEDERAL GOVERNMENT AND THE UNIVERSITY RESEARCH INFRASTRUCTURE

HEARINGS

BEFORE THE

TASK FORCE ON SCIENCE POLICY

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

FIRST SESSION

MAY 21, 22; SEPTEMBER 5, 1985

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[***] Term expired June 30, 1985.
[****] Term commenced July 1, 1985.

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THE FEDERAL GOVERNMENT AND THE UNIVERSITY RESEARCH INFRASTRUCTURE

TUESDAY, MAY 21, 1985

House of Representatives,
Committee on Science and Technology,
Task Force on Science Policy,
Washington, DC.

The task force met, pursuant to call, at 10:10 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the task force) presiding.

Mr. **Fuqua**. This morning our task force begins 2 days of hearings on an important but complex issue, that of the Federal Government's role in providing a research infrastructure at the Nation's research institutions.

This is an issue which, since 1945, seems to come before us periodically. Thus we saw in the 1960's, both the National Science Foundation and National Institutes of Health provided extensive support for research facilities and training facilities. In the 1970's, little concern was expressed about the need for such a role until the end of the decade when the instrumentation obsolescence issue was raised, and in the last 2 years, the request for buildings and building modifications has again come before us.

In addition, our committee has also had to provide for newly emerging infrastructure needs such as supercomputers. These individual research support requirements are all part of the broader set of needs which taken together have come to be termed "research infrastructure." This includes in addition to buildings, instruments, and computers, such things as research libraries, research hospitals, and a wide range of research support personnel such as technicians, assistants, and secretarial staff. In these hearings we have begun our inquiry into what the long-term needs for infrastructure support are likely to be and what the role of the Federal Government should be in meeting those needs. We expect to learn what the other sources of support are, such as State government, private giving, and an extensive system of indirect cost payments which are providing to support and maintain research infrastructure.

We also want to explore the alternative mechanisms that may have been available to provide Federal support for research infrastructure. Should separate categorical programs for the support of individual infrastructure needs, such as, for example, instrumentation and supercomputers, be put in place? Should more general institutional support programs giving more latitude for the individual institutions be used? Or would it be better to increase significantly the payments of indirect costs and through this mechanism provide the funds for infrastruture needs?

All of these are difficult and important questions. We are delighted to have a group of outstanding witnesses to discuss them with us today.

We begin with Benjamin Healy, Deputy Director of the Office of Science and Technology Policy, Executive Office of the President.

Did I say Benjamin? I am sorry, I apologize.

I need new glasses, I guess.

Thank you very much, we will be delighted to hear from you.

[A biographical sketch of Dr. Healy follows:]

BERNADINE HEALY, M.D.[1]

Dr. Bernadine Healy is Deputy Director of the Office of Science and Technology Policy, Executive Office of the President. Her appointment was made by President Reagan and confirmed by the Senate in June of 1984. Prior to that time she was Professor of Medicine at The Johns Hopkins Hospital and School of Medicine.

Dr. Healy was born in New York City, completed secondary school at the Hunter College High School, graduated from Vassar College, summa cum laude, in 1965, and the Harvard Medical School, cum laude, in 1970. She completed advanced post graduate training in internal medicine, anatomic pathology, and cardiovascular disease at The Johns Hopkins School of Medicine. She joined the faculty of medicine and pathology at Johns Hopkins in June 1976 where she had clinical responsibilities and ran an active research program in cardiovascular pathology. In 1977 she became Director of the Coronary Care Unit of The Johns Hopkins Hospital. In 1979 she assumed the additional role of Assistant Dean for Post Doctoral Programs and Faculty Development, a position which included responsibilities for approximately 900 post graduate physicians, and policy issues regarding appointment and academic advancement of the medical faculty.

Dr. Healy has been President of the American Federation of Clinical Research (AFCR), and was Chairman of its Public Policy Committee. She is on the Board of Directors of the American Heart Association, is Chairman of the Scientific Sessions, and has served as Vice President and Chairman of the research Committee of the Maryland affiliate. She has served on the Board of Governors of the American College of Cardiology, was a member of several Advisory Committees to the National Heart, Lung and Blood Institutes and the Cardiovascular Devices Committee of the Food and Drug Administration.

Dr. Healy is the author or co-author of nearly 200 medical and scientific articles, mostly in the area of cardiovascular research and medicine, and has served on the Editorial Boards of numerous scientific journals. She has been a member of the Board of Directors of the Stetler Research Fund for Women Physicians. Dr. Healy is a recipient of the 1983 National Board Award for Medicine of the Medical College of Pennsylvania and is a member of several honorary societies, including Phi Beta Kappa, Alpha Omega Alpha, and the American Society of Clinical Investigation.

In her present position at OSTP she is involved in life sciences and regulatory issues; is the OSTP representative to several panels including the National Cancer Advisory Board and the National Heart, Lung, and Blood Institute Council; is executive secretary of the White House Science Panel's Study on the Health of the Universities; and chairs the White House Cabinet Council Working Group on Biotechnology.

STATEMENT OF DR. BERNADINE HEALY, DEPUTY DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT, WASHINGTON, DC

Dr. **HEALY**. Thank you, Mr. Chairman.

I am pleased to be here today to discuss one of the most important issues affecting the future of our Nation: the health of our university system, and specifically, the condition of the research facilities and equipment in our universities and colleges. I would like to confine my remarks today to the policy issues we face, on the assumption that my colleagues from the universities and industry are in the best position to provide an accurate picture of the physical condition of research infrastructure in our universities.

---

[1] Dr. Healy (formerly Bernadine Healy Bulkley).

Assessing the condition of university research infrastructure is not an easy task. Each university has unique needs and long-term objectives, and is at a unique stage of its own physical and intellectual development. Estimates of the cost of renovating and modernizing the university research infrastructure ranges from about $5 billion to over $20 billion in a period of around 5 years. To get more specific than that often requires arbitrary judgments.

What we do know is that present conditions do not make us especially comfortable about the prospects that our university system will be able to meet our Nation's needs in coming years.

As many of you are aware, for the past year, a Panel of the White House Science Council has been studying the health of our university system. The Panel was asked to address one fundamental question: "Are our colleges and universities prepared to train and educate the talent we need to remain preeminant in an age of rapid technological change and intense competition?"

In a matter of months, the Panel, which is chaired by Mr. David Packard, will release its report. As the Panel has addressed the issue of infrastructure at some length, many of my remarks will resemble those expressed in the forthcoming report. I should stress, however, that I do not claim to speak on behalf of the Panel; and because their work is not yet completed, I will not be able to discuss their recommendations in great detail.

The central issue the Panel is addressing is not merely whether the universities are physically equipped, or have adequate faculty, to train the talent our Nation needs today. The real issue is whether our Nation is in a position to ensure that the universities are able to train such talent consistently and continuously for the foreseeable future. This is a subtle, but important distinction.

We are concerned about more than the specific infrastructure problems we currently face. The American university system is distinctive in that our universities conduct research and education activities simultaneously. In fact, in most graduate programs in science and engineering, the graduate student is being trained while he or she participates in research. Research in universities thus yields a dual dividend: talent and new knowledge. Strengthening the research capabilities of a university by definition strengthens the education capabilities of the university, and vice versa.

The link is important, because it is largely due to the simultaneous practice of research and training that America maintains such undisputed world leadership in science. In no other nation are students trained by such eminent practicing scientists as they are in the United States. That we have won the overwhelming majority of the Nobel Prizes in science in the last decade attests to that success.

But world leadership in technology is a much more complex endeavor. Our technological capabilities reside in a complex interrelationship among Government, industry, and the universities. At the risk of oversimplifying a bit, let me try to describe this interrelationship.

Industry employs scientists and engineers to apply new knowledge to specific problems—the result of which is new technology. The universities' role is to provide new talent, in the form of new scientists and engineers and new knowledge on a continuous basis. Government's role is to provide the climate that promotes the appropriate investment by both the public and private sectors to meet the Nation's present and future demands for talent and new knowledge.

Ideally, this interrelationship is a partnership among the three central institutions. The partnership works best through teamwork, with each partner reinforcing the other's capabilities to respond to the challenges of competition and technological change.

It is industry that is most affected by rapid change; it is industry, too, that most heavily depends on universities to help it adapt and contribute to change. Of the three, industry in particular feels the heat of competition. Industry, therefore, is the key to the universities' ability to adapt to the changing demands of the world around them.

The universities are uniquely able to assess their own immediate strengths and weaknesses. The reason: Because they are nearest to the problems, and because, in their research and teaching activities, they are made aware of society's needs, and their own institutions' abilities to respond to them.

The Government is, however, the only one of the three in a position to take the broad, long-term view. Industry is necessarily concerned about the nearer term—issues like the number of engineers graduated per year in a given field. These issues are resolved in a supply and demand interaction between industry and the universities. But the Government is in a special position to worry about long-term issues like the productivity of the research enterprise, the quality of the talent and new knowledge our universities produce, the overall ability of the universities to adapt and respond to the changing demands of industry and the rest of society, and so on.

These are global needs vital to our Nation that the Federal Government must address, along with our universities, our State and local governments and our industries.

This is why so many say that Federal funding of basic research is an investment. The Government is not buying packages of research results; it is investing in the long-term strength of the research and education enterprise.

So, what does this mean when we discuss the condition of infrastructure in our universities? We all agree that there are deficiencies. But the central question is not so much what to do about the present condition of the university research infrastructure. The real question is more fundamental: Is the partnershp among industry, Government, and the universities functioning in a manner which ensures that the United States will maintain a healthy, modern research infrastructure?

I think most of us would agree that, given its present condition, and in spite of the strengthened commitment to the basic research enterprise which Chairman Fuqua and the Committee on Science and Technology, and many others in Congress have shown in the last several years, the partnership may not be adequate to the task. Although there has been a 30 percent real growth in basic research funding since 1981 and a 23 percent real growth in university basic research funding since 1980, there has been little emphasis on infrastructure. In fact, none of the three partners have fully addressed this issue in the last decade or more, although we have in the last few years begun to see some significant improvement.

After Sputnik, the Government began a whole series of programs of investment in new facilities and equipment. Our research capacity in this Nation expanded rapidly, and the system produced much of the talent and new knowledge upon which today's technological revolution is based.

But in the early 1970's, these investments were discontinued. Construction stopped. By the late 1970's, the universities warned that unless the Government came up with new facilities funding, the research infrastructure was in trouble. Industry was making some contributions, but those were small compared to the benefits they derived from the talent and new knowledge produced by the universities.

For most of the decade of the 1970's and into the early 1980's, the universities themselves behaved largely as dependents of the Government, abdicating their responsibility for infrastructure and biding their time until Federal facilities programs were resumed. And the Government, not fully acknowledging its responsibility for the long-term health of the system, attempted not to invest in the research enterprise, but to procure packets of research results at the lowest possible price.

Facilities use allowance reimbursements, for example, are based on an average useful life of 50 years for a university laboratory. The actual average useful life of a modern laboratory is probably closer to 20 to 25 years, as it is for industrial laboratories. As for research equipment, in addition to having unrealistically long amortization periods—15 years, in contrast to the actual 6 to 8—the Government also micromanages the purchase of new equipment.

Although financial accountability is an integral part of good Federal management, the level of detail required by OMB circular A-110 in documenting the need for any piece of equipment costing more than $5,000 is an unnecessary burden. The Government also requires inventories of all research equipment owned by an institution, presumably to serve as a basis on which to compare the A-110 screening documents.

Well, what should we do? Simply creating a new multibillion dollar facilities program may, over the near term, improve the condition of infrastructure, but it won't restore teamwork to the partnership, or prevent a boom-bust cycle. It is equally important that change take place in the attitudes and performance of each of the three partners.

The Government must focus on our research expenditures as investing in the research enterprise and not just procuring research results. This means bearing the reasonable and necessary costs of the research it sponsors. But it means more than that. As I indicated earlier, the Federal Government shares the responsibility along with the universities to respond and adapt to the changing demands of society. As regards infrastructure specifically, I would say bringing amortization periods for both facilities and equipment into line with those for industry would be a wise and appropriate change. In addition, much of the Federal paperwork and management associated with university research should be reevaluated and eliminated if inappropriate or unnecessarily burdensome.

The universities must assume a far more significant and responsible role in managing the Nation's investment in university research. The Government-university relationship should be a mutually reinforcing, mutually beneficial, equal partnership. I would like, for example, to see a system in which the universities would be reimbursed realistically for facilities and equipment used in Federally-sponsored research and for the universities to take a leadership role in identifying cost savings associated with research overhead.

As for industry, a direct involvement by industry in the university research process offers significant benefits to both. Direct contributions of state-of-the-art research equipment, and industry-university cooperation in its use and maintenance, is one remedy for some of the weaknesses in the partnership. Unrestricted donations, as well as donations toward renovation or new construction of facilities, should be encouraged.

I would anticipate that some of this will cost money. But we must ask ourselves, can our Nation remain competitive in this fast-changing age if we are not training the very best talent we can? An increased Federal commitment to university research is indeed an investment—an investment that we probably cannot get along without. Because only the universities train and educate the talent that is so central to our continued world leadership in both science and technology, university research is the highest priority in the civilian R&D effort.

Yet, of the more than $20 billion we spend on civilian R&D, about $6 billion is invested in university research. This balance may be inapprorpiate to today's circumstances. Since the budget deficit forces us to select from among competing priorities, I would suggest that we continue what we all began several years ago, and redirect civilian R&D funds from lower priority areas, particularly technology development projects, to the highest priority, university-based basic research. This would permit us to be both fiscally responsible and attentive to the need for investment in the future growth, prosperity and leadership of our Nation.

I would be pleased to answer questions. Thank you.

[The prepared statement of Dr. Healy follows:]

PROPOSED REMARKS OF DR. BERNADINE HEALY, M.D.
DEPUTY DIRECTOR
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
EXECUTIVE OFFICE OF THE PRESIDENT

MAY 21, 1985

Mr. Chairman, I am pleased to be here today to discuss one of the most important issues affecting the future of our nation: the health of our university system, and specifically, the condition of the research facilities and equipment in our universities and colleges. I would like to confine my remarks today to the policy issues we face, on the assumption that my collegues from the universities and industry are in the best position to provide an accurate picture of the physical condition of research infrastructure in our universities.

Assessing the condition of university research infrastructure is not an easy task. Each university has unique needs and long term objectives, and is at a unique stage of physical and intellectual development. Estimates of the costs of renovating and modernizing the university research infrastructure range from about $5 billion to over $20 billion in a period of around five years. To get more specific than that would require arbitrary judgments. What we do know is that present conditions do not make us especially comfortable about the prospects that our university system will be able to meet our nation's needs in coming years.

As many of you are aware, for the past year, a Panel of the White House Science Council has been studying the health of our university system. The Panel was created by Dr. George A. Keyworth, the President's Science Advisor, who asked them to address one fundamental question: "Are our colleges and universities prepared to train and educate the talent we need to remain preeminant in an age of rapid technological change and intense competition?"

In a matter of months, the Panel, which is chaired by Mr. David Packard, will release its report. As the Panel has addressed the issue of infrastructure at some length, many of my remarks today will resemble those expressed in the forthcoming report. I should stress, however, that I do not claim to speak on behalf of the Panel; moreover, because their work is not yet completed, I will not be able to discuss their recommendations in great detail.

The central issue the Panel is addressing is not merely whether the universities are physically equipped, or have adequate faculty, to train the talent our nation needs today. The real issue is whether our nation is in a position to ensure that the universities are able to train such talent consistently and continuously for the foreseeable future. This is a subtle, but important distinction.

If I may digress for a moment, I think I can demonstrate to you why we are concerned about more than the specific infrastructure problems we currently face. The American university system is distinctive in that our universities conduct research and education activities simultaneously. In fact, in most graduate programs in science and engineering, the graduate student is being trained while he or she participates in research. Research in universities thus yields a dual dividend: talent and new knowledge. Strengthening the research capabilities of a university by definition strengthens the education capabilities of the university, and vice versa.

The link is important, because it is largely due to the simultaneous practice of research and education that America maintains such undisputed world leadership in science. In no other nation are students trained by such eminent practicing scientists as they are in the U.S. That we have won the overwhelming majority of the Nobel prizes in science in the last decade attests to that success.

But world leadership in technology is a much more complex endeavor. Our technological capabilities reside in a complex interrelationship among government, industry, and the universities. At the risk of oversimplifying a bit, let me try to describe this interrelationship. Industry employs scientists and engineers to apply new knowledge to specific problems--the result of which is new technology. The universities' role is to provide new talent, in the form of new scientists and engineers and new knowledge on a continuous basis. Government's role is to provide the climate that promotes the appropriate investment by both the public and private sectors to meet the nation's present and future demands for talent and new knowledge.

Ideally, this interrelationship is a partnership among the three central institutions. The partnership works best through teamwork, with each partner reinforcing the other's capabilities to respond to the challenges of competition and technological change.

It is industry that is most affected by rapid change; it is industry, too, that most heavily depends on universities to help it adapt and contribute to change. Of the three, industry in particular feels the heat of competition. Industry, therefore, is the key to the universities' ability to adapt to the changing demands of the world around them.

The universities are uniquely able to assess their own immediate strengths and weaknesses. Ask a researcher which wheels need grease--a new NMR machine, larger computing capacity--and he or she can answer immediately. The reason: because they're nearest to the problems, and because, in their research and teaching activities, they are made aware of society's needs, and their own institutions' abilities to respond to them.

The government is, however, the only one of the three in a position to take the broad, long-term view. Industry is necessarily concerned about the nearer term--issues like the number of engineers graduated per year in a given field. These issues are resolved in a supply and demand interaction between industry and the universities. But the government is in a special position to worry about long-term issues like the productivity of the research enterprise, the quality of the talent and new knowledge our universities produce, the overall ability of the universities to adapt and respond to the changing demands of industry and the rest of society, and so on. These are global needs vital to our nation that the federal government must address, along with our universities, our State and local governments and industry.

This is why so many say that federal funding of basic research is an investment. The government is not buying packages of research results; it is investing in the long term strength of the research and education enterprise.

So, what does this mean when we discuss the condition of infrastructure in our universities? We all agree that there are deficiencies. But the central question, I hope I have now explained, is not so much what to do about the present condition of the university research infrastructure. The real question is more fundamental: Is the partnership among industry, government, and the universities functioning in a manner which ensures that the U.S. will maintain a healthy, modern research infrastructure?

I think most of us would agree that, given its present condition, and in spite of the strengthened commitment to the basic research enterpise which Chairman Fuqua and the Committee on Science and Technology, and many others in Congress have shown in the last several years, the partnership may not be adequate to the task. Although there has been a 30% real growth in basic research funding since 1981 and a 23% real growth in university basic research funding since 1980, there has been little emphasis on infrastructure. In fact, none of the three partners have fully addressed this issue in the last decade or more, although we have in the last few years begun to see some significant improvement.

After Sputnik, the government began a whole series of programs of investment in new facilties and equipment. Our research capacity in this nation expanded rapidly, and the system produced much of the talent and new knowledge upon which today's technological revolution is based.

But in the early 1970s, these investments were discontinued. Construction stopped. By the late 1970s, the universities warned that unless the government came up with new facilities funding, the research infrastructure was in trouble. Industry was making some contributions, but those were small compared to the benefits they derived from the talent and new knowledge produced by the universities. The universities themselves behaved largely as dependents of the government, abdicating their responsibility for infrastructure and biding their time until federal facilities programs were resumed. And the government, not fully acknowledging its responsibility for the long term health of the system, attempted not to invest in the research enterprise, but to procure packets of research results at the lowest possible price. Facilities use allowance reimbursements, for example, are based on an average useful life of 50 years for a university laboratory. The actual average useful life of a modern laboratory is probably about 20-25 years, as it is for industrial laboratories. As for research equipment, in addition to having unrealistically long amortization periods--15 years, in contrast to the actual 6 to 8--the government also micromanages the purchase of new equipment. Although financial accountability is an integral part of good federal management, the level of detail required by OMB Circular A-110 in documenting the need for any piece of equipment costing more than $5,000 is an unnecessary burden. The government also requires inventories of all research equipment owned by an institution, presumably to serve as a basis on which to compare the A-110 screening documents.

Well, what should we do? Simply creating a new multi-billion dollar facilities program may, over the near term, improve the condition of infrastructure, but it won't restore teamwork to the partnership. It is equally important that change take place in the attitudes and performance of each of the three partners.

The government must focus on our research expenditures as investing in the research enterprise and not procuring research results. This means bearing the reasonable and necessary costs of the research it sponsors. But it means more than that. As I indicated earlier, the federal government shares the responsibility along with the universities to respond and adapt to the changing demands of society. As regards infrastructure specifically, I would say bringing amortization periods for both facilities *and* equipment into line with those for industry would be a wise and appropriate change. In addition, much of the federal paperwork and management associated with university research should be reevaluated and eliminated if inappropriate or unnecessarily burdensome.

Accordingly, however, the universities must assume a far more significant and responsible role in managing the nation's investment in university research. The government-university relationship should be a mutually reinforcing, mutually beneficial, equal partnership. I would like, for example, to see a system in which the universities would be reimbursed realistically for facilities and equipment used in federally sponsored research and for the universities to take a leadership role in identifying cost savings associated with research overhead.

As for industry, a direct involvement by industry in the university research process offers significant benefits to both. Direct contributions of state-of-the-art research equipment, and industry-university cooperation in its use and maintenance, is one remedy for many weaknesses in the partnership. Unrestricted donations, as well as donations toward renovation or new construction of facilities, should also be encouraged.

I would anticipate that some of this will cost money. But we must ask ourselves, can our nation remain competitive in this fast-changing age if we're not training the very best talent we can? An increased federal commitment to university research is indeed an investment--an investment that we probably can't get along without. Because only the universities train and educate the talent that is so central to our continued world leadership in both science and technology, university research is the highest priority in the civilian R&D effort. Yet, of the more than $20 billion we spend on civilian R&D, about $6 billion is invested in university research. This balance may be inappropriate to today's circumstances. Since the budget deficit forces us to select from among competing priorities, I would suggest that we continue what we all began several years ago, and redirect civilian R&D funds from lower priority areas, particularly technology development projects,

to the highest priority, university based basic research. This would permit us to be both fiscally responsible and attentive to the need for investment in the future growth, prosperity, and leadership of our nation.

I would now be pleased to answer any questions you might have.

DISCUSSION

Mr. **Fuqua**. Thank you very much, Dr. Healy.

That was a very constructive statement, I might add.

Dr. Keyworth has testified before the committee before and discussed in generalities this same issue. The question that I guess comes to my mind is the fact that we are talking about doubling the universities' capacity to produce new Ph.D.'s or even tripling it maybe, by the year 2010 to meet the demands that have been forecast that would be required.

Now, what I am concerned about is are we just trying to meet the current demands and not factoring in that increased number that we are going to need? Do you have any opinion about that?

Dr. **Healy**. I think I——

Mr. **Fuqua**. I hope I am making myself clear.

Dr. **Healy**. Yes, you are, and I quite agree with your concern, and the White House Science Council Panel has been trying to stress the fact that the issue is not whether facilities are adequate or whether the equipment today is adequate, but what about the long-term future? Are we strategically planning? I think this is clearly an issue of broadest and pressing concern. I think the committee such as yours and the White House Science Panel are the kinds that should be addressing these issues. I think industry and the universities now are worried about their budgets and their planning for the next 3 months and the next year.

Mr. **Fuqua**. You would be a hero about your comments about Circular 110.

Dr. **Healy**. Heroine.

Mr. **Fuqua**. Can we expect that to be implemented any time soon?

Dr. **Healy**. Any time soon? Depends how you define soon. As you know, things don't work with real swiftness sometimes.

Mr. **Fuqua**. You also mentioned in your statement about the changing of the amortization schedules and so forth. I think it would be an excellent idea. However, that is more in the long-range and really doesn't address the short-range situation where we are approaching 20 years in some of those that were built in the late 1950's and early 1960's when those programs were then in use, plus the equipment associated with that, too. You also state that the universities themselves behave largely as dependents of the Government, abdicating their responsibilities and biding their time until a Federal program on facilities is resumed. Is there anything that can be done to change the attitude on the part of the universities?

Dr. **Healy**. I think there have been signs of change. I think that was prevalent in the 1970's when people expected big construction grants to be resumed that we saw in the 1960's. I think that most of our major research universities have recognized that they cannot afford to wait for what might come along. I think there are—we are seeing substantial movement and more creative approaches as you have suggested in floating bond issues to renew infrastructure.

But I think that the problem is so large that in all likelihood the universities, when they are doing a substantial amount of federally sponsored research, particularly, cannot handle it alone. I think the Government has to be a partner in it.

To this extent, the universities that have taken the lead in starting to renew their infrastructure and come up with more creative approaches to the problem are not functioning as dependents. I think it is important that they truly be part of that investment partnership with the Federal Government as part of it.

Also, the State governments—I think we are seeing a very exciting motion on the part of State and local governments to become part of this effort both with industry and with universities.

Mr. **Fuqua**. Thank you.

Mr. **Brown**.

Mr. **Brown**. Thank you, Mr. Chairman.

Dr. Healy, I have been looking both at your testimony and at the text of the National Science Engineering and Technology Policy Priorities Act which this committee spawned several years ago, and I am wondering if there are any defects in language of this act which may have led to development of some of these critical problems, such as the infrastructure problem, and while I must confess to some pride of authorship as far as this committee is concerned in the act—I have a tendency perhaps to gloss over its deficiencies—nevertheless, it seems to me this act clearly places on the Office of Science and Technology Policy the responsibility for ascertaining, in a long-range way, the development of problems of this sort, and recommending to the President and to Congress strategies for dealing with it. I sense that this problem has crept up on us without being faced up to realistically, and yet I don't see from the standpoint of what the Congress could have done, any way to better anticipate than to lay out the responsibilities as we have in this act.

Can you discuss with me why broad problems of this sort can develop without receiving adequate attention and sometimes narrower problems? To give you an example of a narrower problem, I was reading in the last couple days—I think it was the *Scientific American* magazine article—lamenting the lack of support for basic research in mathematics, a fundamentally important field to us, and if this is true, that for 10 years we have been neglecting this, it is a problem that requires some action. Why are we not getting a surfacing of these problems in a more timely fashion and recommendations for solution to them?

Dr. **Healy**. Well, I think that perhaps right now we are. You can argue why has it taken us so long, but I think that one of the things that makes me extremely optimistic is that I think the problems of our research universities, the essentiality of our research universities to the Nation as a whole, is being perceived in a bipartisan fashion and is clearly perceived by the Congress and is perceived by the administration.

I don't think it is a coincidence that, really totally independently, your committee has addressed this issue and the White House Science Office has taken this on. I think that you may be nudging me a bit and suggesting we may have done it a little sooner over at OSTP, but we did start this about a year ago and I think that both your—the congressional efforts and efforts of the administration are trying to remedy perhaps this past fault which is not thinking enough strategically, thinking in terms of procuring packets of research or putting out immediate fires, or dealing with problems in the next few months, rather than saying: "Is this of substantial investment that we must nurture, can we get along with boom and bust approaches to investment, does this require a commitment?"

I think one of the fundamental problems in all our investment in science, as well as in universities, is the perception that because we renegotiate the budget every year and go through the hassles of the budget process, we are somehow renegotiating the commitment to invest in our scientific enterprise. The nature of the scientific enterprise is one that you cannot for a moment question the importance of that investment. It is not an entitlement program. It is not a subsidy program that can be subject to cancellation or severence; it is the essence of our productivity and our future.

I sense, and I suspect you do as well, that at this point in time, people are aware of that perhaps as never before. The problems have been developing a long time. I don't see that they will be solved overnight, but I think there is a bipartisan and rather widespread and rather vocal commitment to the fact that things must change.

Mr. **Brown**. Well, I obviously pick on the administration or any agency of it that I can from time to time, and one of the things that I pick on in OSTP is that rarely do they seem to have read the act. There is, for example, within this act the emphasis upon the importance of supporting high quality basic research which this administration has to be commended for encouraging. On the other hand, there is also the emphasis upon the *Five-Year Outlook*, and annual reports of developing problems in science which I cannot commend this administration for doing much about and in fact, they seem to have shorted it considerably over the period of years.

Now, I think that is the appropriate role for us in Congress to point out where you are doing things right and where you are not doing things right, and I hope that we can continue that, but specifically I see nothing that represents a timely response to the admonitions contained here to maintain a continuing surveillance over all of the aspects that relate to the health of science in this country, and I question whether possibly your office has the resources to accomplish this.

As far as this committee is concerned, I think we would like to give you those resources but we get very little encouragement in trying to do that.

Dr. **Healy**. Well, I would agree with you, I think that the Office of Science and Technology Policy, which is a very small policy office within the EOP, does not have the resources to fulfill the task outlined in the act, and I think there is no place else within the executive branch of Government that that is being carried out in a global way.

Sometimes even within agencies—for example, our wonderful NIH—you don't even have a global strategic look at the overall $5 billion investment there. It tends to be separated up into individual institutes. So I think that the importance of strategic 5-year looks at our overall research enterprise, both within very broad categorical areas and also across the Government in general when we are investing $50 billion in research, is important.

I would agree with you. It must be done better than it is being done. As you know, the President's Commission on Industrial Competitiveness recommended that there be a Department of Science. And I really believe—and as you know Dr. Keyworth in the Office has supported that—and I believe that that was not a self-serving support, but rather a recognition of the fact that when you have something which is so essential to the fabric of our Nation, it affects all walks of life, all people, and that you don't have a coordinated opportunity within the administration to look at science in its broadest pespective, to bring it to the table, to examine it in a strategic way, that there is a problem. It needs to be remedied. I think the support for the Department of Science and Technology was not a bureaucratic escalation. It really was an attempt in part to respond to the very spirit of that act you are speaking about.

Mr. **Brown**. I sensed that that was the case, and I commend the results of that work. I note also looking at broad approaches to some of the problems in science that face us, that the National Academy has recently done a study of international competitiveness of some of our basic industries. I would suspect that that was an unaccustomed task for the Academy because they had to look at a wide range of nonscientific problems that relate and couple that with the science and technology problems in order to reach a conclusion. But they did and they emerged with some rather good results in my opinion. If the Academy can go through that strain, I don't see why the Office of the President cannot go through that strain and tie together some of these pressing national problems and this is the language, the authority is contained in the language of the act.

There is no question about that. But there is reluctance in any administration—I am not just picking on this one—to carry out functions which they don't quite perceive, they don't quite—it doesn't quite fit into their priority scheme for meeting the needs of the country. We suffer as a consequence of that.

Dr. **Healy**. Well, believe it or not, I read that act in great detail and I think that it should be taken seriously and often the advice of acts like that need to be accompanied by a check.

Mr. **Brown**. We sometimes find that Science Advisors are not willing to admit that until after they have left office, however.

Dr. **Healy**. I hope that is not a premonition.

Mr. **Brown**. Thank you.

Mr. **Fuqua**. Thank you.

Mr. Lujan.

Mr. **Lujan**. Thank you, Mr. Chairman.

I think my colleague from California missed the last point that it ought to be accompanied by a check. He didn't comment on that.

I think you have made an excellent presentation, which you made very well, to show the relationship between industry, universities and the Government and what each of our responsibilities are. There is an emphasis as there should be in this particular hearing on university research. And with that emphasis, and coming from the office that you do—Dr. Keyworth maybe right at the very beginning, as a matter of fact, got into trouble with some of his colleagues at the Government laboratories by saying more of this should be done over at the university level rather than the Government laboratories—at least that is what I understood at the time, being a great advocate of the laboratories since they exist in my home district. But is it the feeling of OSTP that we don't do enough in university research? You mentioned $6 billion of the $20 billion in civilian research, that only that amount goes to universities. You don't think that is enough?

Dr. **Healy**. Well, I think that I don't have the means to answer that question, but I think that question needs to be asked and I think that is a fundamental and quite strategic question that needs to be asked.

Is it roughly $16 billion being spent in our Federal laboratory systems?

Mr. **Lujan**. If you take defense it is 40.

Dr. **Healy**. It is more, yes. One question is not necessarily to dismantle our Federal laboratory systems, which are superb, but rather to ask whether there could be better use of those facilities by some of our private research universities, more operation with the Federal laboratories and industry.

As you know, Mr. David Packard chaired the Federal laboratory study which OSTP completed over a year ago with a strong recommendation that there be more use of the Federal laboratories by the private sector, both the universities and the industries. That isn't as far along as it should be perhaps.

Mr. **Lujan**. But basically I keep getting the feeling that OSTP feels that we have to beef up that university research rather than just continue it as it was. The reason I ask that question——

Dr. **Healy**. Yes.

Mr. **Lujan** [continuing]. What this whole thing is about is what should our science policy be and should that policy be that a larger percentage of the R&D budget go to the universities? That is a very crucial question we will have to address in the report.

Dr. **Healy**. I would say that it is fair to say that the general feeling is that the university-based research should be the No. 1 priority; that the very unique system of doing so much of our first class basic research out in a diverse and complicated system of private universities, the diversity of that system is such an important part of its creativity. And I think that it is the feeling of the Office and of the Panel that that should be the No. 1 priority, and that that again may mean that $6 billion is not enough.

But I cannot say, and I don't think the Panel is going to say, *x* billion is what we need. I think that that question has to be asked and I think that the answer is likely to be this is not a zero sum game.

Mr. **Lujan**. I am just wondering, as an aside, if OSTP does different kinds of studies? And what leads me to that question is one of the witnesses the other day had a chart of postgraduate students in this country and showed how many were U.S. nationals and how many were nationals of other countries, and probably paid for by their governments to go to school. And I remember the bottom line which was engineers, that only something less than 50 percent of postgraduate engineering students were U.S. nationals, and I had never thought about it until just now, but I am wondering if those do enroll in universities that are well funded or that we have good research programs with? Is OSTP in a position to do that kind of study?

Dr. Healy. We, as part of the University Panel, were looking at the foreign students that were coming into the research universities here and interestingly, the consensus of the Panel, and also of a questionnaire in which we solicited opinion from the outside community and in hearings we held in general, was that the foreign students at research universities are a very positive force.

Mr. Lujan. Do they take up the room or just——

Dr. Healy. We tend to get the very best and that in fact is a positive, net positive for the intellectual environment of our universities. There was really no sense, and frankly this surprised me, because in the field of medicine which is my background, somewhat different, there was not the sense that they were taking positions away from American students.

Mr. Lujan. There was room over and above what we required?

Dr. Healy. There was more than just room, there was a need. They were not producing enough in some of these areas on our own, among our own, and we needed to have some of this talent.

Mr. Lujan. That is interesting.

Thank you very much.

Mr. Fuqua. Thank you very much, Dr. Healy. We appreciate your being here and for your remarks this morning.

Our next witness will be Henry G. Kirschenmann, Deputy Assistant Secretary for Procurement, Assistance, and Logistics at the Department of Health and Human Services.

We would be pleased to hear from you.

[A biographical sketch of Mr. Kirschenmann follows:]

Henry G. Kirschenmann, Jr.

Henry G. Kirschenmann, Jr. is the Deputy Assistant Secretary for Procurement, Assistance and Logistics in the Department of Health and Human Services. As such he is one of the Department's chief career officials and advisors to the Office of the Secretary in the grant and procurement area. He is also responsible for developing audit resolution policy and overseeing the process within the Department.

Prior to being appointed to his current position, Mr. Kirschenmann served in various financial management positions in the Department and at the National Institutes of Health. He was involved in developing and implementing cost policy and other financial management policy for colleges and universities and other non-profit organizations, State and local governments and hospitals which receive grants and contracts from the Department. He was also involved in establishing indirect cost rates. Mr. Kirschenmann has served with the Defense Contract Audit Agency, was a staff member of the national accounting firm of Price Waterhouse and Company, and has held various positions in industry.

He holds a Bachelor's Degree from the University of Maryland, a Master's Degree from The American University and is a certified public accountant. He is the recipient of Senior Executive Performance Awards, the Department of Health, and Human Service's Superior Service Award, and two achievement awards and the President's Citation from the Association of Government Accountants.

STATEMENT OF HENRY G. KIRSCHENMANN, JR., DEPUTY ASSISTANT SECRETARY, PROCUREMENT, ASSISTANCE AND LOGISTICS, DEPARTMENT OF HEALTH AND HUMAN SERVICES

Mr. Kirschenmann. Thank you, Mr. Chairman. It is a pleasure to be here.

I and my Department are pleased to assist the task force in its study of Government science policy by providing information on payments for indirect costs to colleges and universities. As we understand it, the task force is interested in knowing the amounts of indirect costs paid to the institutions as part of the total costs of research grants and contracts, as well as the extent to which these payments support the research infrastructure of the institutions.

We have endeavored to meet the task force's request and have developed a substantial amount of information on this subject which we believe you will find useful. The information, in the form of a series of charts and graphs, is attached to my statement. I note, however, that the amounts and percentages on indirect costs shown in the charts are approximations based on an analysis of available information on total Federal R&D obligations to colleges and universities, NIH indirect cost payments, and components of indirect cost rates, supplemented by detailed information on certain indirect cost subcomponents provided by 50 major research universities.

In order to put this information in perspective, some background on indirect costs might be useful. Indirect costs are the costs of administrative and supporting services which cannot be readily identified with specific research projects, instructional programs, or other university activities. They are therefore grouped in a series of cost pools and allocated between research and other activities based on cost allocation procedures.

The portion of indirect costs allocated to research is then further distributed to individual research projects by an indirect cost rate, which is expressed as a percentage of direct research costs. The institutions negotiate these rates annually with a "cognizant" Federal agency. HHS is the cognizant agency for about 95 percent of the colleges and universities receiving Federal research, although some of the major institutions, such as MIT and Stanford, negotiate their rates with the Department of Defense.

Universities generally have six principal components of indirect costs:

One, use allowances or depreciation on buildings and equipment. Use allowances are essentially a simplified form of depreciation;

Two, operation and maintenance of facilities, which covers such costs as utilities, janitorial services, repairs and maintenance, and similar expenses;

Three, general administration, encompassing the institution's executive offices, administrative services, such as accounting and purchasing, and other costs of a general nature;

Four, departmental administration, consisting of the expenses of deans' offices and administrative expenses at the academic department level;

Five, sponsored projects administration, which are specialized services related to the management of sponsored research and training, such as review of grant applications and monitoring grant terms and conditions;

Six, the costs of institutional libraries, including the salaries of library staff and books and periodicals.

With that as background, I would now like to turn to the specific information requested by the task force, as detailed in the attached charts:

Total Federal R&D obligations to colleges and universities have gone from $1.9 billion in fiscal year 1972 to over $5 billion in fiscal year 1983, an increase of about 160 percent. Specific year-by-year information is shown in graph and chart 1.

GRAPH 1

TOTAL FEDERAL R & D OBLIGATIONS TO COLLEGES AND UNIVERSITIES

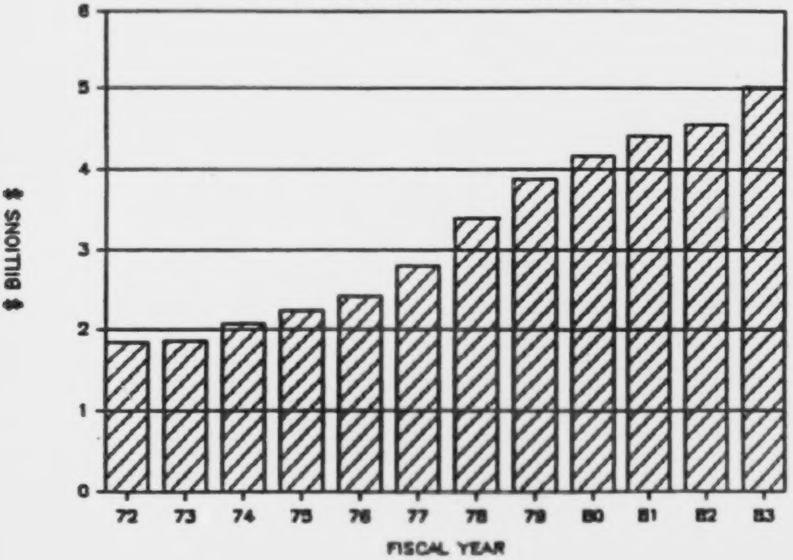

CHART 1

TOTAL FEDERAL R & D OBLIGATIONS TO COLLEGES AND UNIVERSITIES (IN MILLIONS OF DOLLARS)

		-----AWARDING AGENCY-----			
	TOTAL	HHS	DOD	NSF	OTHERS
72	1,853	879	244	335	307
73	1,871	904	233	349	386
74	2,085	1,129	184	376	396
75	2,246	1,205	191	405	446
76	2,431	1,296	212	437	486
77	2,803	1,452	267	491	593
78	3,386	1,658	452	532	744
79	3,874	1,967	529	588	791
80	4,160	2,026	556	634	945
81	4,411	2,113	700	617	981
82	4,553	2,111	814	690	939
83	5,022	2,360	913	759	989
84	------DATA NOT YET AVAILABLE FROM NSF------				

SOURCE: TABLE B-2 -- FEDERAL OBLIGATIONS TO UNIVERSITIES AND COLLEGES IN NSF'S PUBLICATION 'FEDERAL SUPPORT TO UNIVERSITIES, COLLEGES AND SELECTED NONPROFIT INSTITUTIONS'.

As shown in graph and chart 2, during the same 1972 to 1983 period, total estimated indirect cost payments by all Federal agencies have increased by 275 percent, from about $400 million to $1.5 billion. At NIH, indirect costs are now running about 32 percent of total university research grant costs, up from 22 percent in 1972. This disproportionate growth in indirect costs, in comparison with direct costs, has been a concern to sponsoring agencies and the research community for some time, and is currently being reviewed by the White House Office of Science Technology Policy.

GRAPH 2

APPROXIMATE AMOUNT PAID TO COLLEGES AND UNIVERSITIES FOR INDIRECT COSTS UNDER R & D AWARDS BY ALL FEDERAL AGENCIES

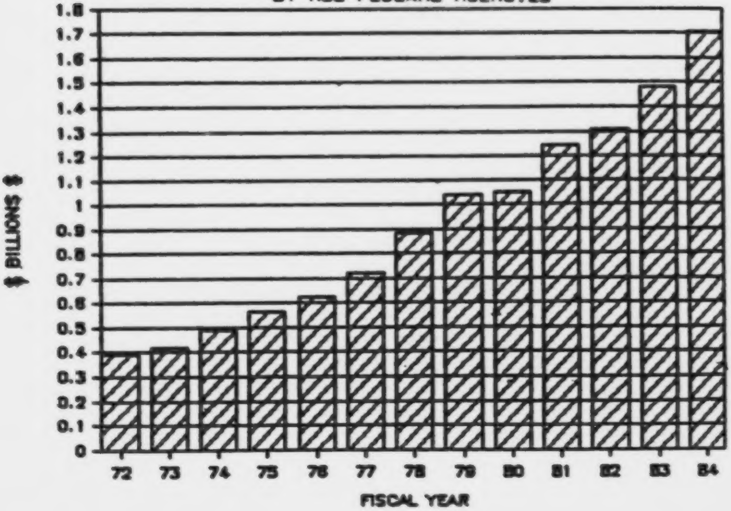

CHART 2

APPROXIMATE AMOUNT PAID TO COLLEGES AND UNIVERSITIES
FOR INDIRECT COSTS UNDER R & D AWARDS
BY ALL FEDERAL AGENCIES
(IN MILLIONS OF DOLLARS)

72	393
73	419
74	491
75	562
76	624
77	720
78	885
79	1,039
80	1,050
81	1,247
82	1,310
83	1,480
84	1,706
TOTAL	11,925

Based on an analysis of fiscal year 1982 through 1984 indirect cost rates negotiated by HHS, the largest component of indirect costs is departmental administration, which averages one-third of the rate. Operation and maintenance of facilities is next at 28 percent, followed by general administration at 15 percent. Use allowances on buildings and equipment is currently running between 9 percent and 10 percent of the rate; sponsored projects administration is 7 percent; and library is 4 percent. What that translates to is administrative cost equalling about 55 percent of the rate as opposed to such things as use charges and operation and maintenance facilities cost.

CHART 3

AVERAGE PERCENT OF EACH COST COMPONENT TO THE TOTAL INDIRECT COST RATE FOR MAJOR RESEARCH UNIVERSITIES NEGOTIATED BY HHS

COST COMPONENTS	1982	1983	1984
USE ALLOWANCES/DEPRECIATION ON BUILDINGS & EQUIPMENT	9%	9%	10%
OPERATION AND MAINTENANCE OF PHYSICAL PLANT	27%	28%	28%
GENERAL ADMINISTRATION	17%	15%	15%
DEPARTMENTAL ADMINISTRATION (INCLUDING DEANS' OFFICES)	32%	33%	33%
SPONSORED PROJECTS ADMINISTRATION	7%	7%	7%
LIBRARY	5%	4%	4%
STUDENT SERVICES	1%	0%	0%
OTHER	2%	3%	3%
TOTAL RATE	100%	100%	100%

The rest is in minor items, such as a small portion of student service costs associated with students working on research projects. As indicated in chart 3, these percentages have held reasonably steady for the 3-year period. Chart 4 shows the rate components expressed as a percentage of direct research costs.

CHART 4

AVERAGE INDIRECT COST RATE COMPONENTS
FOR MAJOR RESEARCH UNIVERSITIES NEGOTIATED BY HHS

COST COMPONENTS	1982	1983	1984
USE ALLOWANCES/DEPRECIATION ON BUILDINGS & EQUIPMENT	4.2	4.3	4.5
OPERATION AND MAINTENANCE OF PHYSICAL PLANT	12.0	12.8	13.3
GENERAL ADMINISTRATION	7.4	7.1	7.3
DEPARTMENTAL ADMINISTRATION (INCLUDING DEANS' OFFICES)	14.2	15.2	15.4
SPONSORED PROJECTS ADMINISTRATION	3.3	3.2	3.1
LIBRARY	2.1	2.0	2.0
STUDENT SERVICES	0.6	0.2	0.1
OTHER	1.0	1.2	1.4
TOTAL RATE	44.7	46.0	47.1

RATES ARE EXPRESSED AS A PERCENTAGE OF TOTAL DIRECT COST OF ORGANIZED RESEARCH EXCLUDING CAPITAL EXPENDITURES, MAJOR SUBCONTRACTS AND OTHER DISTORTING ITEMS.

Chart 5 shows the approximate dollar amount paid to the institutions for each indirect cost component from fiscal year 1982 to 1984. The total amount paid during this period was about $4.5 billion, broken down in round numbers as follows:

Use allowances, $400 million; operation and maintenance, $1.2 billion; general administration, $700 million; departmental administration, $1.5 billion; sponsored projects administration, $300 million; library, $200 million; other, $150 million.

CHART 5

APPROXIMATE AMOUNT PAID TO UNIVERSITIES FOR INDIRECT COST COMPONENTS BY ALL FEDERAL AGENCIES (IN MILLIONS OF DOLLARS)

COST COMPONENTS	1982	1983	1984	---3 YEAR--- TOTALS	RATIO
USE ALLOWANCES/DEPRECIATION ON BUILDINGS & EQUIPMENT	123	138	163	424	9%
OPERATION AND MAINTENANCE OF PHYSICAL PLANT	351	412	482	1245	28%
GENERAL ADMINISTRATION	216	228	264	709	16%
DEPARTMENTAL ADMINISTRATION (INCLUDING DEANS' OFFICES)	415	489	558	1462	33%
SPONSORED PROJECTS ADMINISTRATION	97	103	112	312	7%
LIBRARY	62	64	72	198	4%
STUDENT SERVICES	18	6	4	28	1%
OTHER	29	39	51	119	3%
TOTALS	1310	1480	1706	4496	100%

Charts 6, 7, and 8 take this indirect cost component analysis one step further, to more detailed breakouts of each indirect cost component into various subcomponents which we thought might be of interest to the task force. These are very rough approximations based on estimates provided to us by 50 major research universities or information on these institutions in our regional negotiation files.

CHART 6

AVERAGE PERCENT OF EACH COST RATE COMPONENT AND SUBCOMPONENT TO THE TOTAL INDIRECT COST RATE FOR MAJOR RESEARCH UNIVERSITES NEGOTIATED BY HHS

COST COMPONENTS	1982		1983		1984	
	COMPONENT	SUBCOMPONENT	COMPONENT	SUBCOMPONENT	COMPONENT	SUBCOMPONENT
USE ALLOWANCES/DEPRECIATION	9%		9%		10%	
-BUILDINGS/IMPROVEMENTS		4%		4%		4%
-EQUIPMENT		5%		5%		6%
OPERATION AND MAINTENANCE OF PHYSICAL PLANT	27%		28%		28%	
-UTILITIES		12%		12%		12%
-REPAIRS & MAINTENANCE		6%		6%		6%
-CUSTODIAL SERVICES		5%		5%		5%
-SECURITY		1%		1%		1%
-OTHER		3%		4%		4%
GENERAL ADMINISTRATION	17%		15%		15%	
-EXECUTIVE MANAGEMENT		3%		3%		3%
-FINANCIAL OPERATIONS		3%		3%		3%
-ADMINISTRATIVE SERVICES		5%		4%		4%
-OTHER		6%		5%		5%
DEPARTMENTAL ADMINISTRATION	32%		33%		33%	
-DEANS' OFFICES		8%		8%		8%
-DEPT. HEADS & FACULTY ADM.		11%		11%		11%
-SUPPORT STAFF		7%		7%		7%
-OTHER		6%		7%		7%
SPONSORED PROJECTS ADMINISTRATION	7%		7%		7%	
-OFFICE OF GRANTS & CONTRACTS		5%		5%		5%
-ACADEMIC DEPT. CHARGES		0%		0%		0%
-OTHER		2%		2%		2%
LIBRARY	5%		4%		4%	
-SALARIES & WAGES		2%		2%		2%
-BOOKS & PERIODICALS		1%		1%		1%
-OTHER		2%		1%		1%
STUDENT SERVICES	1%	--	0%	--	0%	--
OTHER	2%	--	3%	--	3%	--
TOTAL RATE	100%		100%		100%	

CHART 7

AVERAGE INDIRECT COST RATE COMPONENTS AND SUBCOMPONENTS FOR MAJOR RESEARCH UNIVERSITES NEGOTIATED BY HHS

COST COMPONENTS	1982 COMPONENT	1982 SUBCOMPONENT	1983 COMPONENT	1983 SUBCOMPONENT	1984 COMPONENT	1984 SUBCOMPONENT
USE ALLOWANCES/DEPRECIATION	4.2		4.3		4.5	
-BUILDINGS/IMPROVEMENTS		1.8		1.9		1.9
-EQUIPMENT		2.4		2.4		2.6
OPERATION AND MAINTENANCE OF PHYSICAL PLANT	12.0		12.8		13.3	
-UTILITIES		5.2		5.5		5.7
-REPAIRS & MAINTENANCE		2.5		2.7		2.8
-CUSTODIAL SERVICES		2.3		2.4		2.5
-SECURITY		0.5		0.6		0.6
-OTHER		1.5		1.6		1.7
GENERAL ADMINISTRATION	7.4		7.1		7.3	
-EXECUTIVE MANAGEMENT		1.3		1.3		1.3
-FINANCIAL OPERATIONS		1.5		1.4		1.5
-ADMINISTRATIVE SERVICES		2.2		2.1		2.2
-OTHER		2.4		2.3		2.4
DEPARTMENTAL ADMINISTRATION	14.2		15.2		15.4	
-DEANS' OFFICES		3.5		3.7		3.8
-DEPT. HEADS & FACULTY ADM.		4.8		5.2		5.3
-SUPPORT STAFF		3.0		3.2		3.2
-OTHER		2.9		3.1		3.1
SPONSORED PROJECTS ADMINISTRATION	3.3		3.2		3.1	
-OFFICE OF GRANTS & CONTRACTS		2.3		2.2		2.2
-ACADEMIC DEPT. CHARGES		0.2		0.2		0.2
-OTHER		0.8		0.8		0.7
LIBRARY	2.1		2.0		2.0	
-SALARIES & WAGES		0.9		0.9		0.9
-BOOKS & PERIODICALS		0.5		0.5		0.5
-OTHER		0.6		0.6		0.6
STUDENT SERVICES	0.6	--	0.2	--	0.1	--
OTHER	1.0	--	1.2	--	1.4	--
TOTAL RATE	44.7		46.0		47.1	

RATES ARE EXPRESSED AS A PERCENTAGE OF TOTAL DIRECT COST OF ORGANIZED RESEARCH EXCLUDING CAPITAL EXPENDITURES, MAJOR SUBCONTRACTS AND OTHER DISTORTING ITEMS.

CHART 8

APPROXIMATE AMOUNT PAID TO UNIVERSITIES
FOR INDIRECT COST COMPONENTS AND SUBCOMPONENTS
BY ALL FEDERAL AGENCIES
(IN MILLIONS OF DOLLARS)

COST COMPONENTS	1982 COMPONENT	1982 SUBCOMPONENT	1983 COMPONENT	1983 SUBCOMPONENT	1984 COMPONENT	1984 SUBCOMPONENT	3 YEAR TOTALS COMPONENT	3 YEAR TOTALS SUBCOMPONENT
USE ALLOWANCES/DEPRECIATION	123		138		163		424	
-BUILDINGS/IMPROVEMENTS		53		60		70		183
-EQUIPMENT		70		78		93		241
OPERATION AND MAINTENANCE OF PHYSICAL PLANT	351		412		482		1,245	
-UTILITIES		152		178		206		536
-REPAIRS & MAINTENANCE		73		88		100		259
-CUSTODIAL SERVICES		67		78		92		236
-SECURITY		15		18		21		54
-OTHER		44		52		61		156
GENERAL ADMINISTRATION	216		228		264		708	
-EXECUTIVE MANAGEMENT		39		41		48		128
-FINANCIAL OPERATIONS		43		46		53		141
-ADMINISTRATIVE SERVICES		64		67		78		219
-OTHER		70		74		85		229
DEPARTMENTAL ADMINISTRATION	415		489		558		1,462	
-DEANS' OFFICES		102		120		137		359
-DEPT. HEADS & FACULTY ADM.		142		167		190		499
-SUPPORT STAFF		87		102		116		305
-OTHER		85		100		114		299
SPONSORED PROJECTS ADMINISTRATION	97		103		112		312	
-OFFICE OF GRANTS & CONTRACTS		68		72		78		218
-ACADEMIC DEPT. CHARGES		6		6		7		19
-OTHER		23		25		27		75
LIBRARY	62		64		72		198	
-SALARIES & WAGES		27		28		31		86
-BOOKS & PERIODICALS		16		17		19		52
-OTHER		19		19		22		60
STUDENT SERVICES	18	--	6	--	4	--	28	28
OTHER	28	--	40	--	51	--	119	119
TOTALS	1,310		1,480		1,706		4,496	4,496

This analysis shows, for example, that of the $424 million paid for building and equipment use allowances from 1982 to 1984, approximately $183 million was for buildings and $241 million for equipment. Similarly, of the $198 million paid for library expenses, $146 million was attributable to library staff and operating expenses while $52 million covered books and periodicals.

Depending upon how broadly one defines "research infrastructure," some or all of these components or subcomponents of indirect costs might be viewed as infrastructure costs. It seems clear that, as a minimum, the building and equipment use allowance components would constitute part of the infrastructure. The same could be said of part or all of the operation and maintenance component. The library and other components represent various types of technical or administrative support, which might also be considered part of the infrastructure, depending on the purpose to be served.

That concludes my prepared statement, Mr. Chairman. I hope this information proves useful to the task force in its study and would be glad to respond to any questions the task force may have about the data.

[The prepared statement of Mr. Kirschenmann follows:]

STATEMENT

BY

HENRY G. KIRSCHENMANN, JR.

DEPUTY ASSISTANT SECRETARY FOR PROCUREMENT, ASSISTANCE AND LOGISTICS
DEPARTMENT OF HEALTH AND HUMAN SERVICES

BEFORE THE

TASK FORCE ON SCIENCE POLICY
COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

TUESDAY, MAY 21, 1985

Mr. Chairman and Members of the Science Policy Task Force:

We are pleased to be able to assist the Task Force in its study of Government science policy by providing information on payments for indirect costs to colleges and universities. As we understand it, the Task Force is interested in knowing the amounts of indirect costs paid to the institutions as part of the total costs of research grants and contracts as well as the extent to which these payments support the research infrastructure of the institutions.

We have endeavored to meet the Task Force's request and have developed a substantial amount of information on this subject which we believe you will find useful. The information, in the form of a series of charts and graphs, is attached to my statement. I must emphasize, however, that the amounts and percentages on indirect costs shown in the charts are rough approximations based on an analysis of available information on total Federal R & D obligations to colleges and universities, NIH indirect cost payments, and components of indirect cost rates, supplemented by detailed information on certain indirect cost subcomponents provided by 50 major research universities.

In order to put this information in perspective, some background on indirect costs might be useful. Indirect costs are the costs of administrative and supporting services which cannot be readily identified with specific research projects, instructional programs or other university activities. They are therefore grouped in a series of cost pools and allocated between research and other activities based on cost allocation procedures. The portion of indirect costs allocated to research is then further distributed to individual research projects by an indirect cost rate, which is expressed as a percentage of direct research costs. The institutions negotiate these rates annually with a "cognizant" Federal agency. HHS is the cognizant agency for about 95% of the colleges and universities receiving Federal research, although some of the major institutions, such as MIT and Stanford, negotiate their rates with the Department of Defense.

Universities generally have six principal components of indirect costs:

1. Use Allowances or Depreciation on buildings and equipment. (Use allowances are essentially a simplified form of depreciation.)

2. Operation and Maintenance of facilities, which covers such costs such as utilities, janitorial services, repairs and maintenance, and similar expenses.

3. General Administration, encompassing the institution's executive offices, administrative services, such as accounting and purchasing, and other costs of a general nature.

4. Departmental Administration, consisting of the expenses of deans' offices and administrative expenses at the academic department level.

5. Sponsored Projects Administration, which are specialized services related to the management of sponsored research and training, such as review of grant applications and monitoring grant terms and conditions.

6. The costs of institutional Libraries, including the salaries of library staff and books and periodicals.

With that as background, I would now like to turn to the specific information requested by the Task Force as detailed in the attached charts:

- o Total Federal R&D obligations to colleges and universities have gone from $1.9 billion in FY 1972 to over $5 billion in FY 1983, an increase of about 160%. Specific year-by-year information is shown in Graph and Chart 1.

- o As shown in Graph and Chart 2, during the same 1972 to 1983 period, total estimated indirect cost payments by all Federal agencies have increased by 275%, from about $400 million to $1.5 billion. At NIH, indirect costs are now running about 32% of total university research grant costs, up from 22% in 1972. This disproportionate growth in indirect costs, in comparison with direct costs, has been a concern to sponsoring agencies and the research community for some time, and is currently the subject of a study by the White House Office of Science and Technology Policy.

- o Based on an analyis of FY 1982 through 1984 indirect cost rates negotiated by HHS, the largest component of indirect costs is Departmental Administration, which averages one-third of the rate. Operation and Maintenance of facilities is next at 28%, followed by General Administration at 15%. Use Allowances on buildings and equipment is currently running between 9% and 10% of the rate; Sponsored Projects Administration is 7%; and Library is 4%. The rest is in minor items, such as a small portion of student service costs associated with students working on research projects. As indicated in Chart 3, these percentages have held reasonably steady for the three-year period. Chart 4 shows the rate components expressed as a percentage of direct research costs.

- Chart 5 shows the approximate dollar amount paid to the institutions for each indirect cost component from FY 1982 to 1984. The total amount paid during this period was about $4.5 billion, broken down (in round numbers) as follows:

-- Use Allowances	$400 million
-- Operation & Maintenance	$1.2 billion
-- General Administration	$700 million
-- Departmental Administration	$1.5 billion
-- Sponsored Projects Administration	$300 million
-- Library	$200 million
-- Other	$150 million

- Charts 6, 7 and 8 take this indirect cost component analysis one step further, to more detailed breakouts of each indirect cost component into various subcomponents we thought might be of interest to the Task Force. These are very rough approximations based on estimates provided to us by 50 major research universities or information on these institutions in our regional negotiation files. This analysis shows, for example, that of the $424 million paid for building and equipment use allowances from 1982 to 1984, approximately $183 million was for buildings and $241 million for equipment. Similarly, of the $198 million paid for library expenses, $146 million was attributable to library staff and operating expenses while $52 million covered books and periodicals.

Depending on how broadly one defines "research infrastructure", some or all of these components or subcomponents of indirect costs might be viewed as "infrastructure" costs. It seems clear that, as a minimum, the building and equipment use allowance components would constitute part of the infrastructure. The same could be said of part or all of the Operation and Maintenance component. The Library and other components represent various types of techical or administrative support, which might also be considered part of the infrastructure, depending on the purpose to be served.

That concludes my prepared statement Mr. Chairman. I hope this information proves useful to the Task Force in its study and would be glad to respond to any questions the Task Force may have about the data.

GRAPH 1

TOTAL FEDERAL R & D OBLIGATIONS
TO COLLEGES AND UNIVERSITIES

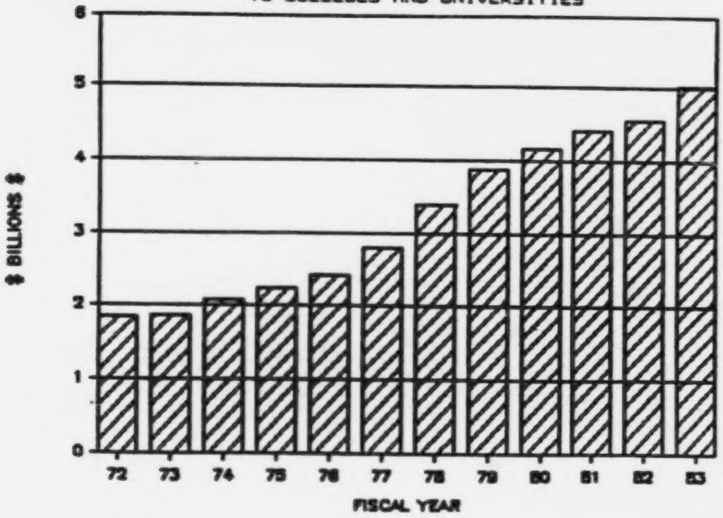

CHART 1

TOTAL FEDERAL R & D OBLIGATIONS TO COLLEGES AND UNIVERSITIES (IN MILLIONS OF DOLLARS)

		-----AWARDING AGENCY-----			
	TOTAL	HHS	DOD	NSF	OTHERS
72	1,853	879	244	335	307
73	1,871	904	233	349	386
74	2,085	1,129	184	376	396
75	2,246	1,205	191	405	446
76	2,431	1,296	212	437	486
77	2,803	1,452	267	491	593
78	3,386	1,658	452	532	744
79	3,874	1,967	529	588	791
80	4,160	2,026	556	634	945
81	4,411	2,113	700	617	981
82	4,553	2,111	814	690	939
83	5,022	2,360	913	759	989
84	------DATA NOT YET AVAILABLE FROM NSF------				

SOURCE: TABLE B-2 -- FEDERAL OBLIGATIONS TO UNIVERSITIES AND COLLEGES IN NSF's PUBLICATION "FEDERAL SUPPORT TO UNIVERSITIES, COLLEGES AND SELECTED NONPROFIT INSTITUTIONS".

GRAPH 2

APPROXIMATE AMOUNT PAID TO COLLEGES AND UNIVERSITIES FOR INDIRECT COSTS UNDER R & D AWARDS BY ALL FEDERAL AGENCIES

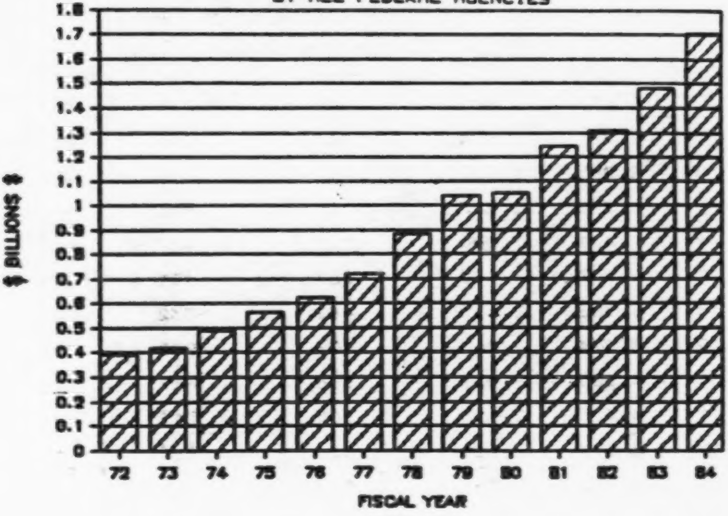

CHART 2

APPROXIMATE AMOUNT PAID TO COLLEGES AND UNIVERSITIES FOR INDIRECT COSTS UNDER R & D AWARDS BY ALL FEDERAL AGENCIES (IN MILLIONS OF DOLLARS)

72	393
73	419
74	491
75	562
76	624
77	720
78	885
79	1,039
80	1,050
81	1,247
82	1,310
83	1,480
84	1,706
TOTAL	11,925

CHART 3

AVERAGE PERCENT OF EACH COST COMPONENT TO THE TOTAL INDIRECT COST RATE FOR MAJOR RESEARCH UNIVERSITIES NEGOTIATED BY HHS

COST COMPONENTS	1982	1983	1984
USE ALLOWANCES/DEPRECIATION ON BUILDINGS & EQUIPMENT	9%	9%	10%
OPERATION AND MAINTENANCE OF PHYSICAL PLANT	27%	28%	28%
GENERAL ADMINISTRATION	17%	15%	15%
DEPARTMENTAL ADMINISTRATION (INCLUDING DEANS' OFFICES)	32%	33%	33%
SPONSORED PROJECTS ADMINISTRATION	7%	7%	7%
LIBRARY	5%	4%	4%
STUDENT SERVICES	1%	0%	0%
OTHER	2%	3%	3%
TOTAL RATE	100%	100%	100%

CHART 4

AVERAGE INDIRECT COST RATE COMPONENTS FOR MAJOR RESEARCH UNIVERSITIES NEGOTIATED BY HHS

COST COMPONENTS	1982	1983	1984
USE ALLOWANCES/DEPRECIATION ON BUILDINGS & EQUIPMENT	4.2	4.3	4.5
OPERATION AND MAINTENANCE OF PHYSICAL PLANT	12.0	12.8	13.3
GENERAL ADMINISTRATION	7.4	7.1	7.3
DEPARTMENTAL ADMINISTRATION (INCLUDING DEANS' OFFICES)	14.2	15.2	15.4
SPONSORED PROJECTS ADMINISTRATION	3.3	3.2	3.1
LIBRARY	2.1	2.0	2.0
STUDENT SERVICES	0.6	0.2	0.1
OTHER	1.0	1.2	1.4
TOTAL RATE	44.7	46.0	47.1

RATES ARE EXPRESSED AS A PERCENTAGE OF TOTAL DIRECT COST OF ORGANIZED RESEARCH EXCLUDING CAPITAL EXPENDITURES, MAJOR SUBCONTRACTS AND OTHER DISTORTING ITEMS.

CHART 5

APPROXIMATE AMOUNT PAID TO UNIVERSITIES FOR INDIRECT COST COMPONENTS BY ALL FEDERAL AGENCIES (IN MILLIONS OF DOLLARS)

COST COMPONENTS	1982	1983	1984	---3 YEAR--- TOTALS	RATIO
USE ALLOWANCES/DEPRECIATION ON BUILDINGS & EQUIPMENT	123	138	163	424	9%
OPERATION AND MAINTENANCE OF PHYSICAL PLANT	351	412	482	1245	28%
GENERAL ADMINISTRATION	216	228	264	709	16%
DEPARTMENTAL ADMINISTRATION (INCLUDING DEANS' OFFICES)	415	489	558	1462	33%
SPONSORED PROJECTS ADMINISTRATION	97	103	112	312	7%
LIBRARY	62	64	72	198	4%
STUDENT SERVICES	18	6	4	28	1%
OTHER	29	39	51	119	3%
TOTALS	1310	1480	1706	4496	100%

CHART 6

AVERAGE PERCENT OF EACH COST RATE COMPONENT AND SUBCOMPONENT TO THE TOTAL INDIRECT COST RATE FOR MAJOR RESEARCH UNIVERSITES NEGOTIATED BY HHS

COST COMPONENTS	1982		1983		1984	
	COMPONENT	SUBCOMPONENT	COMPONENT	SUBCOMPONENT	COMPONENT	SUBCOMPONENT
USE ALLOWANCES/DEPRECIATION	9%		9%		10%	
-BUILDINGS/IMPROVEMENTS		4%		4%		4%
-EQUIPMENT		5%		5%		6%
OPERATION AND MAINTENANCE OF PHYSICAL PLANT	27%		28%		28%	
-UTILITIES		12%		12%		12%
-REPAIRS & MAINTENANCE		6%		6%		6%
-CUSTODIAL SERVICES		5%		5%		5%
-SECURITY		1%		1%		1%
-OTHER		3%		4%		4%
GENERAL ADMINISTRATION	17%		15%		15%	
-EXECUTIVE MANAGEMENT		3%		3%		3%
-FINANCIAL OPERATIONS		3%		3%		3%
-ADMINISTRATIVE SERVICES		5%		4%		4%
-OTHER		6%		5%		5%
DEPARTMENTAL ADMINISTRATION	32%		33%		33%	
-DEANS' OFFICES		8%		8%		8%
-DEPT. HEADS & FACULTY ADM.		11%		11%		11%
-SUPPORT STAFF		7%		7%		7%
-OTHER		6%		7%		7%
SPONSORED PROJECTS ADMINISTRATION	7%		7%		7%	
-OFFICE OF GRANTS & CONTRACTS		5%		5%		5%
-ACADEMIC DEPT. CHARGES		0%		0%		0%
-OTHER		2%		2%		2%
LIBRARY	5%		4%		4%	
-SALARIES & WAGES		2%		2%		2%
-BOOKS & PERIODICALS		1%		1%		1%
-OTHER		2%		1%		1%
STUDENT SERVICES	1%	--	0%	--	0%	--
OTHER	2%	--	3%	--	3%	--
TOTAL RATE	100%		100%		100%	

CHART 7

AVERAGE INDIRECT COST RATE COMPONENTS AND SUBCOMPONENTS FOR MAJOR RESEARCH UNIVERSITES NEGOTIATED BY HHS

COST COMPONENTS	-----1982-----		-----1983-----		-----1984-----	
	COMPONENT	SUBCOMPONENT	COMPONENT	SUBCOMPONENT	COMPONENT	SUBCOMPONENT
USE ALLOWANCES/DEPRECIATION	4.2		4.3		4.5	
-BUILDINGS/IMPROVEMENTS		1.8		1.9		1.9
-EQUIPMENT		2.4		2.4		2.6
OPERATION AND MAINTENANCE OF PHYSICAL PLANT	12.0		12.8		13.3	
-UTILITIES		5.2		5.5		5.7
-REPAIRS & MAINTENANCE		2.5		2.7		2.8
-CUSTODIAL SERVICES		2.3		2.4		2.5
-SECURITY		0.5		0.6		0.6
-OTHER		1.5		1.6		1.7
GENERAL ADMINISTRATION	7.4		7.1		7.3	
-EXECUTIVE MANAGEMENT		1.3		1.3		1.3
-FINANCIAL OPERATIONS		1.5		1.4		1.5
-ADMINISTRATIVE SERVICES		2.2		2.1		2.2
-OTHER		2.4		2.3		2.4
DEPARTMENTAL ADMINISTRATION	14.2		15.2		15.4	
-DEANS' OFFICES		3.5		3.7		3.8
-DEPT. HEADS & FACULTY ADM.		4.8		5.2		5.3
-SUPPORT STAFF		3.0		3.2		3.2
-OTHER		2.9		3.1		3.1
SPONSORED PROJECTS ADMINISTRATION	3.3		3.2		3.1	
-OFFICE OF GRANTS & CONTRACTS		2.3		2.2		2.2
-ACADEMIC DEPT. CHARGES		0.2		0.2		0.2
-OTHER		0.8		0.8		0.7
LIBRARY	2.1		2.0		2.0	
-SALARIES & WAGES		0.9		0.9		0.9
-BOOKS & PERIODICALS		0.5		0.5		0.5
-OTHER		0.6		0.6		0.6
STUDENT SERVICES	0.6	--	0.2	--	0.1	--
OTHER	1.0	--	1.2	--	1.4	--
	-----		-----	-----	-----	-----
TOTAL RATE	44.7		46.0		47.1	

RATES ARE EXPRESSED AS A PERCENTAGE OF TOTAL DIRECT COST OF ORGANIZED RESEARCH EXCLUDING CAPITAL EXPENDITURES, MAJOR SUBCONTRACTS AND OTHER DISTORTING ITEMS.

CHART 8

APPROXIMATE AMOUNT PAID TO UNIVERSITIES FOR INDIRECT COST COMPONENTS AND SUBCOMPONENTS BY ALL FEDERAL AGENCIES (IN MILLIONS OF DOLLARS)

COST COMPONENTS	1982 COMPONENT	1982 SUBCOMPONENT	1983 COMPONENT	1983 SUBCOMPONENT	1984 COMPONENT	1984 SUBCOMPONENT	3 YEAR TOTALS COMPONENT	3 YEAR TOTALS SUBCOMPONENT
USE ALLOWANCES/DEPRECIATION	123		138		163		424	
-BUILDINGS/IMPROVEMENTS		53		68		70		193
-EQUIPMENT		70		70		93		241
OPERATION AND MAINTENANCE OF PHYSICAL PLANT	381		412		482		1,240	
-UTILITIES		182		178		208		538
-REPAIRS & MAINTENANCE		73		85		100		259
-CUSTODIAL SERVICES		67		79		92		238
-SECURITY		15		18		21		54
-OTHER		44		52		61		156
GENERAL ADMINISTRATION	216		228		264		708	
-EXECUTIVE MANAGEMENT		39		41		40		120
-FINANCIAL OPERATIONS		43		46		53		141
-ADMINISTRATIVE SERVICES		64		67		78		210
-OTHER		70		74		93		239
DEPARTMENTAL ADMINISTRATION	418		489		555		1,462	
-DEANS' OFFICES		102		120		137		359
-DEPT. HEADS & FACULTY ADM.		142		167		190		499
-SUPPORT STAFF		87		102		114		303
-OTHER		88		100		114		299
SPONSORED PROJECTS ADMINISTRATION	97		103		112		312	
-OFFICE OF GRANTS & CONTRACTS		68		72		78		218
-ACADEMIC DEPT. CHARGES		6		6		7		19
-OTHER		23		25		27		75
LIBRARY	62		64		72		198	
-SALARIES & WAGES		27		28		31		86
-BOOKS & PERIODICALS		16		17		19		52
-OTHER		19		19		22		60
STUDENT SERVICES	10	--	6	--	4	--	20	20
OTHER	29	--	39	--	51	--	119	119
TOTALS	1,310		1,400		1,786		4,496	4,496

Notes to Charts

1. Total payments for indirect costs by all Federal agencies in Chart 2 are estimates based on the amount of indirect costs paid to universities by NIH each year as a percentage of total NIH research grant obligations to the institutions for the same year. The percentage for each year was applied to total Federal R & D obligations to universities published by NSF to arrive at the approximate amount paid for indirect costs by all Federal agencies.

2. NSF has not as yet published Government-wide data on R & D obligations for FY 1984. Consequently, the estimated indirect cost amount for FY 1984 in Chart 2 is based on the rate of growth between 1983 and 1984 in NIH research grant obligations applied to the 1983 Government-wide R & D data published by NSF.

3. Average indirect cost rate components for FY 1982 to 1984 in Charts 3 and 4 are averages for the approximately 120 largest research universities that negotiate their indirect cost rates with HHS. Universities that negotiate their rates with the Department of Defense are not included. Universities under HHS negotiation cognizance receive about 80% of total Federal R & D obligations. The 120 largest schools used to develop the averages receive over 70% of the total Federal R & D obligations.

4. The approximate dollar amounts paid for each indirect cost component in Chart 5 were developed by multiplying the percentage for each of the average rate components in Chart 3 by the estimated total Government-wide indirect cost payments for FY 1982, 1983 and 1984 in Chart 2.

5. The breakdowns of rate components into subcomponents in Charts 6, 7, and 8 are very rough approximations based on estimates provided by 50 large research universities or information on these institutions in HHS negotiation files.

DISCUSSION

Mr. Fuqua. Thank you very much.

This will certainly be very helpful to us in what we are trying to do.

I understand that rates for each indirect cost category are negotiated separately with each of the universities. Does the Government verify later as a followup that these sums were in fact expended by the instiutions for the purposes intended?

Mr. Kirschenmann. Yes, we do, Mr. Chairman. That process takes place in two steps. We have a force of negotiators throughout the country that review each of the proposals that are submitted and those proposals are based on an institution's audited financial statement for the most part, and a number of institutions are also subjected to audit on site by our audit agency. So the answer to your question is yes.

Mr. Fuqua. Well, you were here earlier for the testimony of Dr. Healy when she was talking about the—making the basis significantly shorter for depreciation for buildings, from 50 years down to a shorter period of time, and also for instruments. How would you view that?

Mr. Kirschenmann. In my view, that is a policy decision based upon what it is that one intends these reimbursements to accomplish at a university. The current rules are based on the conventional accounting concepts of a going concern which is that an institution should be reimbursed for the costs associated with the conduct of a given project and that assumes certain conventions such as the base on the useful life of an asset, however that asset—however long that asset can be kept in service.

One could reimburse this on some basis other than that. I would point out, however, that the cost principles right now are quite flexible on what they would permit an institution to do. For the most part, institutions use a use charge in claiming reimbursement for facilities. That use charge is 2 percent for buildings which assumes a 50-year life, and about 16⅔ percent for equipment—excuse me, 6⅔ percent for equipment, which assumes a 16 or 17 year life.

The cost principles permit an institution to depreciate those assets over its useful life to the institution which would in most cases be substantially less if they want to. Most institutions do not now. I hope I have answered your question. That was a wordy response.

Mr. Fuqua. Well, in your chart 2 the amount of indirect paid to universities is about $1.19 billion.

Mr. Kirschenmann. Yes.

Mr. Fuqua. If use charges remain constant at approximately 9 to 10 percent, would we be correct to infer that in the same time period just over $1 billion was provided to the universities in building and equipment use charges?

Mr. Kirschenmann. Yes, sir, that is correct. That equates to about $100 million a year.

Mr. Fuqua. Do you have any idea how they spent that money? Did any of it go back to refurbishment of the buildings, replacement of equipment?

Mr. Kirschenmann. We know how they spent the sums reimbursed for operation and maintenance, which is repair and janitorial services and so on. Those moneys were spent for that purpose. We don't know how they actually spent the cash that they received for the amortization, use charges on the building itself. We do know they spent that money initially and all we are doing is reimbursing them for that past expenditure. Whether they actually took the cash that they received and reinvested that in plant or they used it for some other purposes, we don't know.

Mr. Fuqua. Or for operating expense?

Mr. Kirschenmann. Or for operating expense, we don't know.

Mr. Fuqua. Or paying salaries?

Mr. Kirschenmann. That is correct.

Mr. Fuqua. But your followup doesn't reveal that?

Mr. Kirschenmann. No, it doesn't. It doesn't.

Mr. Fuqua. Do you think it should?

Mr. Kirschenmann. Well, only if you—under the current concept, no. We really don't care what they use the cash for.

Mr. Fuqua. Yes, OK.

Mr. Kirschenmann. Yes.

Mr. Fuqua. And they have contractual arrangements, too.

Mr. Kirschenmann. Yes; if that is important to the Government as a policy, we could, yes.

Mr. Fuqua. Mr. Brown.

Mr. Brown. It seems to me, Mr. Kirschenmann, that this system would allow for some alleviation of the problems with the universities, if it were treated as a tool trying to alleviate the problems. In other words, if the problem is inadequate equipment and facilities, then what you have allowed is, indirect cost for use allowance could be used to amortize new facilities and equipment. If the amount were large enough to be substantial, it might mean that you would have to reexamine whether or not the current amount, which you say is running between 9 and 10 percent, is adequate, maybe it would take 15 or 20 percent to handle the problems that are surfacing in these institutions, which vary from institution to institution, of course. There is no theoretical reason why that couldn't be done, and then the increased use allowance could be used to make the mortgage payments on the new facilities and equipment.

Mr. Kirschenmann. There is no real reason other than the accounting convention, that is correct. One might also develop a policy which would reimburse an institution for its mortgage payment until such time as that facility is paid for and then subsequent to that, one might have a policy that no further charge can be made to the government, there are all——

Mr. Brown. I am using mortgage in the broad sense. If the institution had the flexibility both to reimburse they could proceed in some reasonable basis to acquire the things that they needed and then to defray some portion of the cost at least out of the user fee that they received.

Mr. Kirschenmann. Yes, sir.

Mr. Brown. I don't know that you can answer this question or not, but you refer to the fact that a study is being made by the White House Office of Science and Technology Policy, and I assume that that study might make some recommendations with regard to this kind of issue. Is that a correct assumption?

Mr. **Kirschenmann.** I believe they are looking at alternatives and may make a recommendation. Dr. Healy would be in better position to answer than I am.

Mr. **Brown.** It is quite obvious that this isn't a static situation in view of the fact that you have had 50-percent increase in indirect costs over the last 12 years.

Mr. **Kirschenmann.** That is correct.

Mr. **Brown.** Are you familiar with the increase cost ratios that are applied by various types of private enterprise to direct labor costs?

Mr. **Kirschenmann.** Yes, sir.

Mr. **Brown.** For example, an engineering firm that has a contract with the Government to perform a certain task would apply an indirect cost to their direct labor cost in order to determine some reasonable figure. Can you give me an idea what kind of ratios might be customary in those?

Mr. **Kirschenmann.** Those rates are very, very high compared to university rates. I think if you take the manufacturing overhead, and engineering overhead, and G and A, the most large R&D or manufacturing firms defense industry particularly apply, you are talking about well over 100 percent. I am not sure that is a fair comparison.

Mr. **Brown.** I am not sure it is either. Some intermediate—that may set the limit to what a fair comparison would be?

Mr. **Kirschenmann.** Yes, sir.

Mr. **Brown.** And the question, what goals are we trying to achieve? Now, in a private contract, the firm is going to make sure that its billings provide the income necessary to keep its equipment and facilities up to date, I presume.

Mr. **Kirschenmann.** Yes, I would presume, yes, sir.

Mr. **Brown.** So that if we were interested in achieving that for university research, we might want to have a little more flexibility in those indirect costs.

Mr. **Kirschenmann.** Yes, sir, what I don't know, what I can't respond to you right now, is the percentage of that industrial overhead rate that is applicable to its facilities.

Mr. **Brown.** I understand that, part of it would be their profit margin.

Mr. **Kirschenmann.** That is also in there, that is right.

Mr. **Brown.** And, of course, we don't normally associate that profit margin with university research.

Mr. **Kirschenmann.** That is correct.

Mr. **Brown.** We are getting a bonus there.

Mr. **Kirschenmann.** Yes, sir.

Mr. **Brown.** That is correct.

Mr. **Fuqua.** Mr. Lewis.

Mr. **Lewis.** Thank you, Mr. Chairman.

I understand that the indirect cost category rates are negotiated separately with each university. Does the Government come back and audit in these areas and determine how and where the indirect funding was expended, or is the university in a position to—uncompromising position like some of our defense contractors—deal with indirect cost?

Mr. **Kirschenmann**. We do know with reasonable certainty that where these costs that are being reimbursed are incurred. As I mentioned to the Chairman, the only area we do not know is whether the actual cash that is reimbursed to a school for its capital, amortization use charges and so forth, is actually used to replace though. We don't know that, but we do know that all the other expenditures, all the other claims that they make, this charge that they make, in the indirect cost proposals are in fact expended for those purposes, yes, sir.

Mr. **Lewis**. Is that done on an annual audit or audit per contractor?

Mr. **Kirschenmann**. Well, it is done annually or semiannually by our negotiations staff in the field, and then there are periodic audits, onsite audits, by audit agencies of at least a major institution. That is not done every year, but it is done sufficiently often, I think, to give us reasonable assurance what the institutions identified in their proposal actually do spend.

Mr. **Lewis**. Is there a possibility that we could see a fixed base contract, fixed contracts for the institutions that *x* number of dollars for a particular project that they have the right to spend anywhere they want without an audit?

Mr. **Kirschenmann**. Well, one could have that policy. I think what people like myself, from the administrative side that has to go back in and look at those charges, would like is some definition, some reasonable definitive statement as to what it is those moneys are to be expended for and to what extent there would need to be an accountability for them and, for example, how one computes that amount. But given those caveats, I think it could be done; yes.

Mr. **Lewis**. Do we have a situation where one university or one group could submit RFP's for particular projects rather than then go after a grant after that to make it more competitive?

Mr. **Kirschenmann**. I am sorry, I didn't understand the question.

Mr. **Lewis**. I didn't understand it myself. Rather than apply for a grant, is there some way universities could be more competitive for research programs, rather than just apply for a grant?

Mr. **Kirschenmann**. Well, my sense of the Research Grants Program certainly at our department, NIH, is that it is highly competitive. I don't know whether you would get any more competition by moving into the procurement arena as opposed to the grant arena. I have sat in on a number of study group evaluations of proposals, and I can tell you they are very stringent evaluations. I think there is a great deal of competition out there. To answer your question, I don't think you would increase competition by going to the procurement arena.

Mr. **Lewis**. Do we have a situation where you would have a grant issued and at the completion of that grant *x* research has been accomplished, but then a followup grant is issued to another organization or university, and how do you——

Mr. **Kirschenmann**. For the same project?

Mr. **Lewis**. Yes.

Mr. KIRSCHENMANN. I guess that could occur, and I know it occurs. I am really not the best person to ask that question. You would be better served by asking somebody in the scientific area. I do know, for example, that there are instances in which a project, a principal investigator on a project, changes universities and the grant would go with that individual because he is key to the conduct of it.

Mr. LEWIS. Thank you.

Mr. FUQUA. Thank you very much. We appreciate your being with us today, and we will also, without objection, make the entire comments, including the charts, part of the record.

Mr. KIRSCHENMANN. Thank you.

Mr. FUQUA. Next is Dale Corson, Chairman of Government-University-Industry Research Roundtable in the Academy of Sciences.

[A biographical sketch of Dr. Corson follows:]

DR. DALE R. CORSON

Dale R. Corson is President Emeritus, and was the eighth president of Cornell University. He was appointed President by the Board of Trustees on September 5, 1969 after serving since July 1, 1969 as Provost with "full executive and administrative responsibility and authority for the management of Cornell." From July 1, 1977 until June 30, 1979 he served as Chancellor.

Dr. Corson was appointed Provost of Cornell University in 1963 after four years as Dean of the College of Engineering.

He joined the Cornell faculty as an assistant professor of physics in 1946 and helped design the Cornell synchrotron housed in the Newman Laboratory of Nuclear Studies. He was appointed associate professor of physics in 1947, became a full professor in 1952 and was named Chairman of the Department of Physics in 1956, and Dean of the College of Engineering in 1959.

He is co-author of two books, *Electromagnetic Fields and Waves* and *Electromagnetism*, and has written numerous papers for physics journals.

Dr. Corson has been a member of the American Council of Education's Board of Directors and its Commission on Plans and Objectives for Higher Education and the Panel of International Technical Cooperation and Assistance, a subpanel of President Lyndon B. Johnson's Science Advisory Committee. He is a former member of the Executive Committee of the National Association of State Universities and Land Grant Colleges.

He has also been a member of the National Science Foundation's Panel on Science Development Programs and a consultant to the Ford Foundation's Overseas Development and International Affairs Programs. He has also been a member of the New York State Commission on Industrial Research and Development and the New York State Science Advisory Council.

Locally, he is a member of the Board of Directors of the Tompkins County Trust Company in Ithaca. He also serves as a Director of the International Minerals and Chemical Corporation and of the Kmart Corporation.

He is a member of the New York Academy of Sciences, the American Association for the Advancement of Science, and is a fellow of the American Academy of Arts and Sciences. He is also a member of the National Academy of Engineering.

He is listed in *Who's Who in America, American Men and Women of Science, Leaders in Education* and *The International Who's Who.*

Dr. Corson was President of the Association of Colleges and Universities of the State of New York (ACUSNY) from 1974-76. ACUSNY includes, as members, most of the 200 public and private colleges and universities in New York State.

He was Chairman of the Commission on Physicians for the Future, which was established in early 1974 by the Josiah M. Macy, Jr. Foundation in response to the growing controversy relating to an impending physician surplus or shortage in the United States. From 1979 to 1981 he served as Chairman of the National Research Council's Committee on Satellite Power Systems; and was a member of the National Commission on Research. In 1982 he served as Chairman of the Panel on Scientific Communication and National Security, sponsored by the National Academy of Sciences and the National Academy of Engineering. He currently serves as Chairman of the International Advisory Panel on Chinese University Development under World Bank sponsorship.

Dr. Corson was a staff member of the Massachusetts Institute of Technology Radiation Laboratory from 1941–43. He served as a technical advisor in Air Force headquarters in Washington from 1943–45 and received an Air Force Commendation for his achievements during World War II in the introduction of new radar techniques into military air operations. At the end of the war, he joined the staff of Los Alamos Scientific Laboratory, assuming primary responsibility for the organization of Sandia Laboratory, which later became a major engineering facility of the Atomic Energy Commission. He received a Presidential Certificate of Merit in 1948 for his contributions to national defense.

Dr. Corson, a native of Pittsburg, Kansas, received his bachelor of arts degree from the College of Emporia in 1934, his master of arts degree in physics from the University of Kansas, 1935, and his Ph.D. in physics from the University of California in 1938. He was associated with the design and construction of the 60-inch cyclotron at the University of California Radiation Laboratory. He is a fellow of the American Physical Society and a member of Phi Beta Kappa, Tau Beta Pi and Sigma Xi.

Dr. Corson received an honorary doctor of laws degree from Hamilton College in 1973, similar honorary degrees in 1972 from Columbia University, and from Elmira College in 1977. In 1970, the College of Emporia awarded him an honorary doctor of humane letters degree. In 1975 the University of Rochester awarded him an honorary doctor of science degree. He was awarded a distinguished service citation by the University of Kansas Alumni Association in 1972 and, in 1971, received the Outstanding Alumnus of the Year Award from the College of Emporia.

Dr. Corson's hobbies include hiking, mountain climbing, canoeing, photography and sailing.

He is married to the former Nellie E. Griswold and has four children.

STATEMENT OF DR. DALE R. CORSON, PRESIDENT EMERITUS, CORNELL UNIVERSITY, ITHACA, NY; AND CHAIRMAN, GOVERNMENT-UNIVERSITY-INDUSTRY RESEARCH ROUNDTABLE, NATIONAL ACADEMIES OF SCIENCES, WASHINGTON, DC

Dr. Corson. Mr. Chairman, and members of the task force, my name is Dale Corson, and I am chairman of the Government-University-Industry Research Roundtable, sponsored by the National Academies of Sciences and Engineering. I am a physicist by training, and I am the emeritus president of Cornell University. I am happy to appear before you today to talk about the infrastructure for academic research, a topic of great national importance.

To begin with, let me define what I mean by "infrastructure." Definition: By infrastructure for university-based research, I mean the people, the facilities, the necessary equipment, including some very large equipment, the research libraries, and the institutional arrangements best designed to promote effective research. These arrangements extended beyond those between the Federal Government and the research universities. They now include the States and industry.

In discussing these topics, I will be describing a system of national investment in a research enterprise designed to serve best our national interest. I emphasize the word "investment."

Another concept that must characterize the research system is that of partnership.

A concept that I reject is that of procurement in promoting the research enterprise. Research is too unpredictable and too fragile to treat in this way.

Finally, I want to keep the concept of excellence squarely before us.

Let me now discuss the elements of the infrastructural system and let me begin with the people. This is the most important element of all. Without qualified people at all levels, nothing else matters.

I want to emphasize the importance of skilled supporting technical staff and to state my belief that an adequate flow of such people may be in jeopardy. At Cornell University, there are five or six supporting staff for every faculty member. Many of these are unskilled workers and secretaries. Many others, however, are skilled technical staff. These include electronic technicians, instrument makers, and an increasing number are super technicians, operating centralized and complex facilities. This latter group is a growing group of technical workers that we may find in short supply in the future.

I base my concern on the state of high school science and mathematics teaching, which may also jeopardize the flow of scientists themselves. No more than 20 percent of high school students are exposed to physics, and only 50 percent are exposed to as much as 2 years of science of any kind. Only 6 percent of high school students take 4 years of mathematics.

How can we interest enough people in science and engineering to meet our future needs, whether for research scientist or for super-technician careers, given the state of affairs?

Research instruments and research equipment generally have reached a state of obsolescence that limits the amount and the quality of research that is possible in the research universities. In engineering, this is a factor turning young research people away from academic careers. The result is an inability of universities to fill available engineering faculty teaching and research positions. Academic careers are simply not as attractive as are industrial careers. It is ironic that the great interest in computers and computer-related technologies has attracted more and more engineering students at the undergraduate level, but the same technologies are pulling graduates into attractive jobs after the bachelors degree and are deflecting them from graduate study which would prepare them for academic research and teaching careers. In light of this situation, more than half of the young faculty appointments that are being made in engineering are foreign nationals.

There have been more comprehensive studies of the instrumentation and equipment shortages than I can give here. I want to stress that as we learn more and more about the underlying phenomena in the fields we study, we learn more and more about how to measure the things we want to measure. Inevitably, these new measuring instruments are large and expensive—very expensive. What we can do with it, however, is little short of miraculous. Today progress in many fields is limited by the unavailability of instruments that cost hundreds of thousands of dollars.

As the need for very expensive equipment develops, the shared use concept is essential. Shared use is one example of the partnership concept that I believe is so important. Other partnerships must also be developed to magnify the impact of the Federal agency equipment support programs that we have begun in recent years. Company-funded instrumentation programs have been important in selected areas. More directed attention to partnership with the states in sorting out responsibilities for both research and instructional equipment would be beneficial. Finally, opportunities for pooling funds and distributing the debt risk should be explored.

In connection with the equipment problem, and related to the people problem, is the issue of equipment maintenance. The Federal Government, the State governments and the universities must resolve the issue of cost sharing and provide for adequate support staff in this area.

Facilities, as typified by research laboratories, represent another large national need. One must distinguish those cases where new facilities are absolutely essential to the progress of the science in question from those where the science can continue to be done in the old facilities but at the price of less than optimum productivity.

I can put no numbers on the problems. I know of no studies which have provided adequate data. The total need for new and renovated facilities is certainly measured in billions of dollars.

To provide facilities, we need a national program, again based on the partnership concept, that will regularize the facilities appropriation process, that will provide for comprehensive merit review taking into account social and economic factors, as well as scientific merit, and which will leverage Federal funds to the maximum degree possible.

As we develop programs to address these facility needs, we must think about new ways to finance them. Given the magnitude of the problem, and given the degree to which the national welfare depends on solving such problems, the Federal Government must necessarily play the lead role. There is no possiblity, however, that the Federal Government will provide funds in an amount sufficient to relieve the accumulated need.

Various approaches to financing have been proposed for discussion within the Research Roundtable. I put them forward here not as recommendations but as suggestions deserving further examination. I also assume that any national program will include some, or a combination, of these approaches.

Using the terms of the financial world, equity financing can be provided through direct Federal appropriations, set-asides from current federal R&D programs, realistic depreciation charges on Federal research grants and matching funds from universities, from States, from industry and from gifts.

Further leverage on these funds can be provided through debt financing. We must look for a way to use Federal funds as a base for a national program of construction bond issues, preferably tax-exempt, to be amortized over a period of years—say 10 or 15—from one, or a combination, of the equity sources listed above.

The Government-Industry-Research Roundtable, which I represent, will conduct a 2-day conference in July, under joint sponsorship with the Office of Science and Technology Policy and the National Science Board, to explore approaches such as these to provide academic research facilities. We expect to have congressional representation at the conference, of course.

I include research libraries as a part of the research infrastructure. The ways these libraries are opened and used have evolved substantially over the past two decades and they hold the promise for entirely new ways to communicate through the written word. The systems now in place are impressive—in a matter of seconds an investigator can locate any book or other bibliographic material cataloged by any one of the Nation's major research libraries.

There is also the promise of replacing the hard text copy of written material with computer screen readouts or rapid printouts of text that is of interest. This promise is still a long way from materialization, however. In fact, the computerized library systems, as they exist, still have a long way to go to provide the optimum service to scientific investigators. We must find ways to invest in libraries in the same way we invest in other research infrastructure.

Finally, I will discuss the institutional relationships which I think important in promoting research of the quality best designed to serve the national interest. I have already touched on this subject in my discussion of "investment" versus "procurement" concepts.

I want to emphasize that the system we developed following World War II, based on the Bush Report, is an excellent system. However, over the decades the system has adapted to changing conditions and changing requirements by applying patches. The current system of rules, regulations and procedures is inappropriate for the most effective operation of the research system. It is time to take a look at the entire research supporting enterprise to see how it might be simplified and modified to serve the national need more efficiently. To this end, the Research Roundtable is sponsoring a 1-day event on June 5 to explore the issues.

There are other institutional arrangements that are important. With fewer tenure-track positions available, universities must find new ways to appoint more research scientists, and they must find ways to bring "new blood" into their aging faculties.

We have seen the evolution of many cooperative ventures between universities and industry in recent years. The Research Roundtable is conducting a set of case studies of new university-industry alliances to examine what the effects are. A central question to be addressed concerns what new institutional arrangements within universities and within industry are necessary to make the alliances productive?

The most productive research at the frontiers of science demand interdisciplinary approaches. Modifications in Federal funding procedures and in university structure and reward systems are required in order to pursue these opportunities.

Another institutional arrangement worthy of consideration is that by which national laboratories develop programs that are of joint interest with industry and universities.

I will conclude by mentioning, with no detailed discussion or analysis, the most difficult and complex of all infrastructure issues—the appropriate size of the academic research system, the roles of the research universities and their relationship to other institutions in our society.

Our system has been driven by a number of forces since World War II. In the years after that war, there was popular belief that science could solve any societal problem. When that illusion was fading, Sputnik put renewed vigor into our educational and research systems, and there was a period of great vitality. The move to the "Great Society" in the 1960's led to an enormous expansion of our educational system, and we built capacity that we do not now need. As we back away from the concepts of that era, great strains have been introduced. As we seek ways to relieve those strains, we must examine the overall size and scope of the educational and research enterprise. Some parts of the system will need expansion. Other parts will need contraction.

I have no advice on how best to carry out this difficult examination. The Research Roundtable has not come to grips with it.

To sum up: I have interpreted the term "infrastructure" broadly. I see the entire system supporting our national research effort as a national investment enterprise, including many sectors of our society, with the Federal Government necessarily being one of the principal partners. The enterprise is in need of revitalization, and as the task force proceeds with its study, there are two concepts I hope you will keep before you: "investment" and "partnership."

Thank you for the opportunity to discuss these matters with you.

[The prepared statement of Dr. Corson follows:]

U.S. HOUSE OF REPRESENTATIVES
SCIENCE AND TECHNOLOGY COMMITTEE
TASK FORCE ON SCIENCE POLICY

Testimony by Dale R. Corson
on
THE FEDERAL GOVERNMENT AND THE UNIVERSITY RESEARCH INFRASTRUCTURE
May 21, 1985

Mr. Chairman and members of the Task Force. My name is Dale Corson and I am Chairman of the Government-University-Industry Research Roundtable, sponsored by the National Academies of Sciences and Engineering. I am a physicist by training and I am the Emeritus President of Cornell University. I am happy to appear before you today to talk about the Infrastructure for Academic Research, a topic of great national importance.

To begin with, let me define what I mean by "infrastructure".

DEFINITION. By infrastructure for university-based research I mean the people, the facilities, the necessary equipment, including some very large equipment, the research libraries and the institutional arrangements best designed to promote effective research. These arrangements extend beyond those between the federal government and the research universities. They now include the states and industry.

PEOPLE. The people I include are those essential to support efficient research programs. These include technicians, mechanicians, research assistants, secretarial and administrative staff.

FACILITIES. By facilities I mean the buildings, the laboratories, the machine shops, and the specialized technical operation facilities designed to house and to support research projects effectively.

EQUIPMENT. By equipment I mean those essential scientific instruments and machines which are too large and too expensive to be supported on a single principal investigator's grant or contract. As research equipment becomes larger and more expensive, it is increasingly necessary to supply such equipment on an institutional, regional or even national basis.

RESEARCH LIBRARIES. The major research libraries provide the bibliographic foundation of the nation's research effort. They face serious problems as they strive to serve research ends adequately. Among the problems are the requirement, and the opportunity, to use new computer and communications technology, the need to meet expanded expectations for collection coverage, and the need to provide easy access and service reliability. The rapidly rising cost of such services is a major part of the problem.

INSTITUTIONAL ARRANGEMENTS. Here I mean organizational arrangements designed to further the objectives of the relevant research programs. Included are institutional relationships within universities, between universities, between universities and industrial laboratories and, especially, between universities and sponsoring federal agencies and state governments.

In discussing these topics I will be describing a system of national investment in a research enterprise designed to serve best our national interest. I emphasize the word "investment." I will be describing a system intended to make research in science and engineering prosper to the maximum degree possible. To do this, the system must support the enterprise adequately, on a base broad enough to permit the research to progress effectively in any promising direction.

Another concept that must characterize the research system is that of "partnership". Although the partnership must involve many sectors of our society, the research universities and the Federal Government are by far the most important elements of the system. These are the elements that I will be discussing primarily.

Industry and state governments are playing more important roles in the research system, and we must find ways to nurture these relationships. We must bring other institutions of our society into the research supporting system, as well; for example the financial world. We must find ways to finance the provision of facilities and the large equipment so that we do not rely totally on the federal government for the enormous capital outlays required.

A concept that I reject is that of "procurement" in promoting the research enterprise. Over a long time our research system, which has been the envy of the world, has gradually assumed more and more features characteristic of the federal procurement system, designed for the procurement of "things". There has been a trend toward specification of particular research results required and toward the use of the mechanisms of the procurement process to address that requirement. Research is too unpredictable and too fragile to treat in this way.

Finally, I want to keep the concept of "excellence" squarely before us. In the words of the late Philip Handler, former President of the National Academy of Sciences: "In science the best is vastly more important than the next best".

Let me now go back and discuss the elements of the infrastructural system, and let me begin with the people. This is the most important element of all. Without qualified people at all levels, nothing else matters. The most important people of all are the scientists and engineers themselves, and while they do not constitute part of the infrastructure, it is important to consider them in any discussion of science policy. I will not pursue this subject here but I will discuss the issue in a separate letter to the Task Force.

In defining the scope of the study the Task Force stated that "only those aspects of science and engineering education which are directly related to research activities should be covered in the Study". I am unsure of the intent of this statement but I want to emphasize the importance of skilled supporting technical staff and to state my belief that an adequate flow of such people may be in jeopardy.

At Cornell University there are five or six supporting staff for every faculty member. Many of these are custodial staff, other unskilled workers and secretaries. Many others, however, are skilled technical staff supporting the work of the research faculty. These include electronic technicians, instrument makers and other more or less traditional workers. An increasing number, however, are "super technicians", operating centralized and complex facilities. Among these are electron microscopy centers, nuclear magnetic resonance facilities, the very lowest temperature cryogenic laboratories, and crystal growing facilities in "super clean" rooms.

This is a growing group of technical workers that we may find in short supply in the future.

I base my concern on the state of high school science and mathematics teaching, which may also jeopardize the flow of scientists themselves. No more than 20% of high school students are exposed to physics these days, and only 50% are exposed to as much as two years of science of any kind. Only 6% of high school students take four years of mathematics. Further, the number of science teachers in training is declining.

How can we interest enough people in science and engineering to meet our future needs, whether for research scientist or for super technician careers, given this state of affairs? Both the structure and the infrastructure of research may be at risk.

Research instruments and research equipment generally have reached a state of obsolescense that limits the amount and the quality of research that is possible in the research universities. In engineering this has reached proportions that is a factor in turning young research people away from academic careers. The result is an inability of universities to fill available engineering faculty teaching and research positions. Academic careers are simply not as attractive as are industrial careers. It is ironic that the great interest in computers and computer-related technologies have attracted more and more students at the undergraduate level but the same technologies are pulling graduates into attractive jobs after the bachelors degree and are deflecting them from graduate study which would prepare them for academic research and teaching careers.

In light of this situation, more than half of the young faculty appointments that are being made in engineering are foreign nationals.

There have been better comprehensive studies of the instrumentation and equipment shortages than I can give here. I want to stress the large equipment which is required for the best research in some fields. As we learn more and more about the underlying phenomena in the fields we study, we learn more and more about how to measure the things we want to measure. Inevitably, these new measuring instruments are expensive. For example, as we go to smaller and smaller structures in microelectronic technologies, we reach limits where optical photo-lithographic techiques for making the small chip structures are inadequate, and we must go to x-ray lithography and to electron beam writing techniques. The equipment to do this is large and expensive—very expensive. What we can do with it, however, is little short of miraculous.

A technology that has proved of enormous usefulness in studying atomic and molecular structures, including those in living bodies, is nuclear magnetic resonance. Such a machine, large enough to accomodate a human body, costs hundreds of thousands of dollars. The same technology provides powerful analytical tools in fields as diverse as materials science and molecular biology. Today progress in many fields is limited by the unavailability of instruments such as these.

These large and expensive machines are leading to the concept of pooled use. The using pool may be all the interested departments in a single university or it may be a regional facility serving all the research laboratories, university and industrial, in the region. As the need for very expensive equipment develops, the shared use concept is essential.

Shared use is one example of the "partnership" concept that I believe is so important. Other partnerships must also be developed to magnify the impact of the federal agency equipment support programs that have begun in recent years. Company-funded instrumentation programs have been important in selected areas. There appears to be real potential for constructive partnership with the states, especially when one considers the instructional equipment needs which appear to be fully as important as the research needs in many places. Some states have launched substantial programs for upgrading scientific equipment. More directed attention to partnership with the states in sorting out responsibilities for both research and instructional equipment would be beneficial. Finally, debt financing has been used to fund equipment acquisition. Opportunities for pooling funds and distributing the debt risk should be explored.

In connection with the equipment problem, and related to the "people" problem, is the issue of equipment maintenance. As the equipment becomes more sophisticated and expensive, the maintenance technicians require more training and command higher salaries. The federal government, the state governments and the universities must resolve the issue of cost sharing and provide for adequate support staff in this area.

The increasing cost and sophistication of research equipment, and the requirement to develop partnership approaches, as I have outlined above, are straining the current administrative procedures and rules, at both the state and the federal levels. The available procedures require a thorough review.

Facilities, as typified by research laboratories, represent another large national need. It is impossible for me to put any number on the magnitude of the need. One must distinguish those cases where new facilites are absolutely essential to the progress of the science in question, from those where the science can continue to be done in the old facilities, but at the price of less than optimum productivity.

In the essential category are "clean" laboratories for work at the frontier in microelectronics, "contained" laboratories for areas of biotechnology such as recombinant DNA work, facilities to handle toxic waste and perhaps adequate animal care facilities. It is impossible, or at best cost ineffective, to provide such badly needed facilites by renovating old buildings. Research in the fields I have mentioned is facility limited.

In other areas with inadequate facilities, renovation may be both adequate and cost effective. Again I can put no numbers on the problems. I know of no studies which have provided adequate data. The total need for new and renovated facilities is certainly measured in billions of dollars.

To provide facilities, we need a national program, again based on the partnership concept, that will regularize the facilities appropriation process, that will provide for comprehensive merit review taking into account social and economic factors as well as scientific merit, and which will leverage federal funds to the maximum degree possible.

As we develop programs to address these facility needs we must think about new ways to finance them. Given the magnitude of the problem, and given the degree to which the national welfare depends on solving such problems, the federal government must necessarily play the lead role. There is no possibility, however, that the federal government will provide funds in an amount sufficient to relieve the accumulated need.

Various approaches have been proposed for discussion within the Research Roundtable. I put them forward here not as recommendations but as suggestions deserving further examination. I also assume that any national program will include some, or a combination, of these approaches.

Using the terms of the financial world, equity financiang can be provided through direct federal appropriations, set-asides from current federal R and D programs, realistic depreciation charges on federal research grants and matching funds from universities, from states, from industry and from gifts.

Further leverage on these funds can be provided through debt financing. We must look for a way to use federal funds as a base for a national program of construction bond issues, preferably tax-exempt, to be amortized over a period of years—say 10 or 15—from one, or a combination, of the equity sources listed above.

The Government-Industry-Research Roundtable, which I represent, will conduct a two-day conference in July, under joint sponsorship with the Office of Science and Technology Policy and the National Science Board, to explore approaches such as these to provide academic research facilities. Part of the discussion will focus on financing mechanisms. We are bringing experts from the investment banking world into the planning for this conference. We expect to have Congressional representation at the conference, of course.

I include research libraries as a vital part of the research infrastructure. These libraries are essential elements in the preservation and transmission of knowledge and in the creation of new knowledge. The ways these libraries are operated and used have evolved substantially over the past two decades, with consequent expansion in staff, equipment and expense—especially the latter.

New data management technology and new communication technology have given the research scientist research tools not previously available, and these tools hold the promise for entirely new ways to communicate through the written word. The systems now in place are impressive—in a matter of seconds an investigator can locate any book or other bibliographic material cataloged by any one of the nation's major research libraries.

There is also the promise of replacing the hard text copy of written material with computer screen readouts or rapid printouts of text that is of interest. This promise is still a long way from materialization, however. In fact the computerized library systems as they exist, still have a long way to go to provide the optimum service to scientific investigators.

These libraries, with their new library services, are essential elements of the research enterprise. We must find ways to invest in them in the same way we invest in other research infrastructures.

Finally, I will discuss the institutional relationships which I think important in promoting research of the quality best designed to serve the national interest.

I have already touched on this subject in my discussion of "investment" vs "procurement" concepts. Consideration of these concepts leads to study of the entire granting and contracting practices in the support of research. I want to emphasize that the system we developed following World War II, based on the Bush Report and leading to the creation of the National Science Foundation and the greatly expanded National Institutes of Health, is an excellent system.

However, over the decades the system has adapted to changing conditions and changing requirements by applying patches. Substantial bureaucratic accretion has resulted and elements of the system, most notably the infrastructure that we are addressing here today, have gone unattended. The current system of rules, regulations and procedures is inappropriate for the most effective operation of the research system. It is time to take a look at the entire research supporting enterprise to see how it might be simplified and modified to serve the national need more efficiently. To this end, the Research Roundtable is sponsoring a one-day event on June 5 to explore the issues. Participants will include federal agency officials, university officials, research scientists, research administrators and others concerned about the efficacy of the system.

There are other institutional arrangements that are important. I think that new organizational patterns are necessary for the universities. With fewer tenure-track positions available they must find new ways to appoint more research scientists, and they must find ways to bring "new blood" into their aging faculties.

We have seen the evolution of many cooperative ventures between universities and industry in recent years. There are important reasons for these developments. I believe that industry is more dependent on universities than in the past for help in bringing new ideas to the marketplace. The developments in biotechnology are one example. Microelectronics and artificial intelligence are others. These developments have proceeded at a time when universities are resource limited in pursuing research in these fields. So they, too, look to the new industrial alliances with enthusiasm.

The new technologies and the new alliances bring with them pressures on the university for more effective multidisciplinary research and education. The most productive research at the frontiers of science also demand interdisciplinary approaches. At a symposium last year honoring the 1983 American Nobel laureates, several earlier Nobel laureates from a variety of disciplines all said that the most exciting science is developing at the interface between disciplines, not within single disciplines. Modifications in federal funding procedures and in university structure and reward systems are required in order to pursue these opportunities.

The Research Roundtable is conducting a set of case studies of new university-industry alliances to examine what the effects are. What is happening to graduate education in the participating universities? Are the alliances effective in bringing new and important ideas to the market place sooner? What new institutional arrangements within universities and within industry are required to make the alliances productive?

Another institutional arrangment worthy of consideration is that by which the federally supported national laboratories develop programs that are of joint interest with industry and universities. I want only to mention this, without any analysis of the opportunities.

I will conclude by mentioning, with no detailed discussion or analysis, the most difficult and complex of all infrastructure issues—the appropriate size of the academic research system, the roles of the research universities and their relationship to other institutions in our society.

Our system has been driven by a number of forces since World War II. In the years after that war there was popular belief that science could solve any societal problem. When that illusion was fading Sputnik put renewed vigor into our educational and research systems and there was a period of great vitality. The move to the "great society" in the 1960s led to an enormous expansion of our educational system and we built capacity we do not now need. As we back away from the concepts of that era, great strains have been introduced. As we seek ways to relieve those strains we must examine the overall size and scope of the educational and research enterprise. Some parts of the system will need expansion. Other parts will need contraction.

I have no advice on how best to carry out this difficult examination. The Research Roundtable has not come to grips with it. Some states, Michigan for example, are tackling the problem in the context of their own needs.

To sum up: I have interpreted the term "infrastructure" broadly. I see the entire system supporting our national research effort as a national investment enterprise, including many sectors of our society, with the federal government necessarily being one of the principal partners. The enterprise is in need of revitalization and as the Task Force proceeds with its study there are two concepts I hope you will keep before you: "investment" and "partnership".

Thank you for the opportunity to discuss these matters with you.

DISCUSSION

Mr. Brown [acting chairman]. Thank you, Dr. Corson.

I commend you and the Research Roundtable for the initiatives that you are taking. I perceive in these initiatives the possibility of developing the strategies to address a number of the problems that we face if all of your meetings and conferences are successful. I hope they will be.

I brought out earlier in questioning Dr. Healy the fact that many of the things that you are doing are embodied in the Science Policy Act, which placed some of these responsibilities on the President's Science Advisor. I note that in your activities, you are maintaining a close liaison with that office, and I hope that you will consider that what you are doing is an extension to what we have indicated is desirable in that particular piece of legislation.

Let me raise one problem which you will be addressing in some of your activities, but it seems to me to be particularly important, and that is the situation involving maintaining an adequate supply of competent research faculty. In a situation where you may, and in fact have in some parts of the past, recent past, experienced a decline in students, a decline in the number of tenured faculty which the institutions are able to maintain has been part of the decrease in students. At the same time, our needs for the research that would be done by those faculty members is increasing, which seems to perhaps indicate too close a coupling between the teaching and the research activity. We may be needing an increase in research at the same time we are needing a decrease in teaching because of the decline in the number of students.

Now, there are solutions to that problem. One direction, of course, is this greater emphasis on cooperative research between universities and industries, which would provide an outlet for additional university research personnel, and would be beneficial to all concerned, and there are probably other avenues, such as placing a greater emphasis upon the kind of research institutions that are best exemplified by the Max Plank Institutes in Germany.

Is it your feeling that the Research Roundtable might be able to present some attractive solutions to this problem which could be considered in terms of some rather significant changes in the way we organize the research and teaching capabilities of this Nation as a whole?

Dr. CORSON. Well, let me address the problem. Let me say at the beginning that it is going to take the best effort of everybody that can be brought to bear on the problem to deal with these issues, and I want to point out that Dr. Healy is a participant in some of our Roundtable activities; we maintain close link to that office.

When you asked if we can provide solutions, you are asking for a great deal. If you want to talk about illumination and discussion of the problems, we can certainly do that. Let me talk a little bit about the university versus the research institute, which you raised.

We are in a difficult situation in the country right now. The universities are under a great deal of strain in the first place. In the sciences, we have little opportunity to make new faculty appointments in the next decade even because of the bulge of faculty people that came in during the great expansion in the universities in the 1960's in physics and chemistry and mathematics; this is particularly serious. At Cornell, for example, in those three departments in the next decade, unless something special is done, there are no opportunities for more than two or three appointments in all three departments, and all three are large departments.

At the same time, the need for research in areas that are primarily university-based, are to a large degree university-based, is growing. For example, in biotechnology, microelectronics, in artificial intelligence and other computer developments, there is a need for universities to link themselves with industry or for industry to link themselves with universities in bringing these new technologies to the marketplace more rapidly.

A great deal more research is needed in these areas, but the universities have no capacity to appoint the necessary people except in engineering, where there are openings that can't be filled. But in the basic sciences, there is no opportunity to appoint new people, and there is not going to be for a decade. So this means that the universities must develop some new structures, or we must have some new restructure, as you point out.

There is a Soviet model which is research institutes largely divorced from universities. I don't think that is a very good model. A more successful model is this Max Plank Institute, one that you mentioned, which again is divorced from the universities, but I think more closely tied to the universities than in the Soviet case. There is—as Dr. Healy pointed out in her testimony, we built so much strength into our system, where we tied teaching and research, that it seems to me that it by far will be best to serve our national interest if we maintain that link and find ways to solve the problems.

The way we are going to solve the problems, I think, is to build research institutes that are going to be parallel in part, linked to universities, but not with a staff that is full-fledged members of university faculties. They can be adjunct appointments, joint appointments, they can teach classes, the institute people can teach classes, they can supervise graduate students if the arrangements are developed most effectively—the institutes will be separately financed and managed probably. It is good to take all the wisdom anybody can bring to bear in developing these, this relationship, but I think it is essential, if we are to provide research activities that these new fields require, where that activity is based to a large extent in the universities.

I don't know exactly how it is going to go, but these institutes are springing up in biotechnology, microelectronics, and my own strong recommendation is to keep the teaching and the research together. One can make a strong case for the proposition that the role of the university is to teach people to solve difficult, novel problems and that the way we do that is by apprenticing students to people who are themselves solving difficult, novel problems and in the process, we are turning out some of the world's best scientists, and we are producing some of the world's best research.

Mr. **Brown**. Well, I appreciate that response. I think that we have the capability in this country to develop a model which is superior to anything that any other country has done. In each of the other countries that we can look to, the ones that you have mentioned and others, their particular structural pattern arose out of their historical experience, just as ours did. Our superiority is going to consist of developing for ourselves, based on our historical experience, something that is better suited to cope with the problems of the future and the capabilities to analyze and visualize what that structure will be that will give us our leadership in the world.

There are the problems that we have referred to here that need to be overcome. The coupling of research in teaching at a time when they get out of phase, the problems that you have at Cornell, the problems that your teaching is basically disciplinary while the need for interdisciplinary research is growing, and we have to develop a model in which we can combine the strengths of both kinds of systems. And it would be my hope that in your wisdom in the Research Roundtable that you could, at least in stimulating a discussion of these things, pose some alternatives that could be examined critically, and we could develop some answers that will help us to cope with the next generation instead of continually worrying about the failures of the past.

Dr. **Corson**. One of our working groups is addressing this very issue, the changes in the structure of the university among other institutions; it is going to have to take place if we are to meet the challenge adequately. The chairman of that working group is Harold Shapiro, president of the University of Michigan, and the cochairman is Ed Jefferson, who is CEO of Du Pont. We have got some good talent thinking about the problem.

Mr. **Brown**. I think there comes to my mind some of the outstanding interdisciplinary research organizations in this country, of which the Bell Labs and Watson Laboratories at IBM are examples. The research done there is first-rate quality and includes both the applied and basic research. There is also a strong emphasis on teaching; a good number of the staff that I have met there are adjunct professors at some institutions, outstanding institutions generally.

Yet to achieve a proper meld between those facilities, those institutions, and the needs of the great teaching and research universities is going to take some real imagination if we are going to solve our problems.

Dr. **Corson**. I am assured by my efforts over the past 20 years to build that kind of activity at Cornell, and I know some of the things that work, and I know a lot of the things that don't work.

Mr. **Brown**. Thank you, Mr. Chairman.

Mr. **Fuqua** [presiding]. Mr. Lewis.

Mr. **Lewis**. I have no questions.

Mr. **Fuqua**. I have one question, Dr. Corson. Back when you were president of Cornell, and starting after Sputnik when the National Defense Education Act, some of the others, we had some block grant programs at universities then that later changed to more project type grants. Do you see that as having an impact on the decline of some of the infrastructure that we are talking about today? In other words, have we caused our own problem?

Dr. **Corson**. I think the problem is so complex, it is hard to place blame in any one place, but some of the block grant programs were extraordinarily successful. Let me give an example.

In about 1960, the Defense Department started the Materials Research Laboratory venture. ARPA [Advanced Research Projects Agency], was the sponsor. NSF took that over after a few years, and they promoted a series of interdisciplinary laboratories in the materials field. There are something like 11 of those in the first round and a few more were added later.

Those appear to me to be some of the most successful federally-sponsored research efforts going. Those are block grants, at least at Cornell it is, where the grant comes to the university, and the whole program is reviewed very carefully by high level review teams periodically, NSF organizations. The program is administered locally by a steering committee made up of working scientists, university administrators, and I don't know what the freedom is, the degree of freedom—I have forgotten—to use that money for facilities, but we have built with that program large central facilities.

For example, there is a so-called millidegree facility—very lowest temperatures—for doing cryogenic work on superconductivity. A high pressure facility where people have now made solids and are perhaps on the verge of making metallic hydrogen, which will provide a great deal of understanding about some of the fundamental structural possibilities for new materials.

There are crystal growing facilities, clean rooms, maximum cleanliness—these have all been built out of that block grant program with local decision. There is an opportunity to fund young people when a young investigator develops new ideas, where in some of the conventional funding mechanisms there at least would be a long delay, and perhaps you would stand no chance against the established investigators; he can get support based on the confidence of his local peers.

There is the opportunity to support established investigators who want to change fields, who have a new idea. It has been, in my opinion, one of the most successful federally-supported programs—I don't mean at Cornell, but the whole MRL [Material Research Laboratories] around the country—and I applaud that, and I hope there will be more opportunities to go that direction in the future. And I do not believe the program has been abused in any way by this system.

Mr. FUQUA. Thank you very much. We appreciate that.

Mr. BROWN. Before you leave, Dr. Corson, it has occurred to me from time to time that one of the reasons for the excellence of our biological research and our leadership in this area and our general health research might be the fact that we have a model of very close cooperation between our outstanding hospitals in this country and our outstanding medical schools frequently.

I know you can think of many examples of this. Massachusetts General and Harvard and others to the point where over the last 10 years, or 20 years, in establishing new Federal hospitals, veterans hospitals, for example, it has almost become a requirement that they be associated with a medical research facility at a medical school, or something of that sort. That seems to have been healthy, both in terms of fundamental research in biology and medicine and in improved health care for individuals. We are talking about doing something like this in the nonbiological sciences. I am wondering if we shouldn't conceptualize this a little bit more clearly than we have.

It seems to me that what we have seen is almost an accidental growth in this kind of coupling between research and teaching institutions, and that perhaps we should recognize the need to formulate specific policy to encourage this in all of the fields of science.

We are looking at plant biotechnology today as being a neglected area. Perhaps one of the reasons for that is that we don't have that kind of close coupling between research and practice in the plant field that we have had in the human field and that we need to encourage it there as well in physics and chemistry and engineering and all of the other areas that we are talking about.

I don't know how this could be brought about, but it seems to me that this is the line of thinking that we are pursuing in an effort to bridge this gap that seems to exist here.

Dr. CORSON. Let me comment a little bit about the complexities of doing that.

It depends on the nature of the technology at hand and the degree to which the university or the research scientists participate in the application of the science that he helps develop. In medicine, whereas you point out the medical college and the medical college faculty and the teaching hospital is the preeminent place where new medical technology is applied, that is the one place where the people who are doing the research are also the ones who are—the applied scientists who the applied science tests—are carried out in the hospital by the very people who have done it there. They are all MD's that are involved.

If you go to the other extreme, and you go to aeronautical engineering, there is no possibility that the university can become closely involved with the application of the basic science at hand. The scale is simply too large for the university to be closely linked. The scale, whatever the entire price is, must be human scale to have universities directly involved with facilities on campus. To apply high velocity gas dynamics in rocket development is not feasible. The scale is wrong.

At the intermediate range are some of the plant agricultural activities, for example, in plant genetics——developing new seed varieties, disease-resistant seed varieties. These are developed in universities and in university-related experiment stations up to the point where samples of new seed in sufficient quantity to grow a small crop to carry the tests through that implementation stage before the seeds are turned over to large seed companies for quantity production. This is an intermediate situation that is on a scale where the link between the university that does the basic science and the applier of that science can be close enough to make it profitable.

I think we have to look at the technology involved. Some of it is going to be well served by bringing the university and industry close together in the cooperative venture that is typified in a medical school teaching hospital setting. Others of it are going to be on such a scale that it is impractical. I suspect that many of the things that we are talking about in microelectronics and biotechnology are on a scale that make the cooperation profitable.

Mr. **Brown**. Well, I don't want to question the validity of your point there, but it seems to me that the scale is in the eye of the beholder. There has been for 40 years a close working relationship between the Caltech, for example, and Jet Propulsion Laboratory, which has done a lot of work in the aircraft propulsion, aerodynamics and so forth, as well as being the foundation of the space program. I am not sure that they have the best possible coupling there, but they do have a coupling which is important.

Dr. **Corson**. Yes, it is a rather loose coupling.

Mr. **Brown**. Yes, but——

Dr. **Corson**. MIT and Lincoln Laboratory. MIT and Draper Laboratories and all missile guidance.

Mr. **Brown**. If we think in terms of institutional changes for both the universities and industrial research facilities, we might be able to overcome some of these problems of scale that you are talking about.

Dr. **Corson**. I think that we must address those problems and face up to the troubles and find ways of making new relationships work. I think we can.

Mr. **Brown** [presiding]. Thank you very much, Dr. Corson, for your very helpful testimony.

Our last witness this morning is Dr. Edward Hollander, chancellor, Department of Higher Education of New Jersey, and we welcome him here this morning, and we very much appreciate your being able to be here on I understand what is fairly short notice, Dr. Hollander.

Dr. **Hollander**. Yes, sir.

Mr. **Brown**. It is a tribute to your understanding of the importance of the subject that we are discussing, and we are very grateful to you.

STATEMENT OF DR. T. EDWARD HOLLANDER, CHANCELLOR, DEPARTMENT OF HIGHER EDUCATION, STATE OF NEW JERSEY, TRENTON, NJ

Dr. **Hollander**. Thank you very much. I have given you two statements, a longer statement for the record, and then a shorter statement which I would like to present directly to the committee.

Mr. **Brown**. The full statement will appear in the record.

Mr. **Hollander**. Thank you.

Higher education has contributed to national science policy by building a basic research capability upon an intellectual base rooted in the liberal western tradition. Future progress rests upon stimulating the graduate and research capabilities of America's universities as a national policy. One means to achieve this end is a new collaboration between higher education, the State, the Federal Government, and industry.

My purpose here is to call for a renewal of the public role in furtherance of science education at all levels, in furtherance of graduate and research capabilities in the sciences and applied sciences and in the stimulation of the higher education-industry partnership.

Using my own State, New Jersey, as illustration, I will report on how one State has responded to the withering away of national commitment to the infrastructure of higher education. Subsequently, I shall argue for a renewed Federal commitment to complement State efforts.

In New Jersey, Governor Kean is determined to make higher education more entrepreneural. While protecting institutional base budgets from enrollment erosion, he has proposed funding new initiatives on a challenge grant basis, that is, requiring that public and independent institutions compete for new funds. Additionally, the Governor has secured passage of a $90 million bond issue and has directed annual appropriations towards economic development through support of basic and applied research at New Jersey's universities. Still further, he has supported financing of improvement in science and mathematics education at all levels of schooling in the State.

A longstanding and major State commitment to science and technology is New Jersey's support of the intellectual and technological infrastructure of research-oriented institutions. For example, almost half of the State's total appropriation for higher education, or $300 million annually, supports the State's three public universities, Rutgers, the University of Medicine and Dentistry of New Jersey, and the New Jersey Institute of Technology. These funds include support for research facilities, laboratories, and libraries. They permit reduced faculty teaching loads to support research, basic and applied. They support special highly paid distinguished research scientists and humanities. The State finances the graduate programs that educate the Nation's instructors and research scientists. Private funds and Federal support have built and maintained similar efforts at Princeton University and Stevens Institute of Technology.

The point is that this Nation's university-based research capacity has been built and is maintained in large measure by State government.

New in New Jersey this year is Governor Kean's challenge to New Jersey's higher education institutions to reach for national status through improved quality. The State is helping Rutgers University to increase its operating budget by $60 million annually, over a 3-year period. The new funds will strengthen the university's research capability by financing the recruitment of world-class scholars, young faculty members and graduate assistants. New funds will enhance the library and finance computer acquisitions. A similar program has been established for the State's technological university, the New Jersey Institute of Technology.

Complementary challenge grant programs have been established for all of the State's teaching institutions. A challenge grant fund of up to $30 million, over 3 years, will strengthen the nine State colleges. A fund that could reach over $25 million is dedicated to providing competitive grants for technological equipment acquisitions and computer applications at all public and private institutions. Over $3 million has already been provided to retrain primary and secondary school teachers of mathematics and science. New teacher training requirements emphasize liberal education with a required major in a field of study in the sciences, social sciences, or the humanities. Remedial education is required to be provided to every freshman admitted to a public college who is deficient in verbal or mathematical ability. Competitive challenge grant funds also are available to strengthen education in the humanities, foreign languages, global education, and the improvement of teaching.

Merit-based scholarships for undergraduates and State graduate fellowships tell students we care about scholarship and intellectual development. All of these efforts and others are designed to strengthen quality in undergraduate teaching, with emphasis in science and technology.

These efforts are complemented by the new funding of science and technology as recommended by the report of the Commission on Science and Technology.

The Commission, after an 18-month study, proposed a program for economic development using the State's research universities. Peer review teams identify fields of priority development in the State and select institutions best able to undertake collaborative research with industry. State funding is contingent upon matching industry funds for research activity. State capital funds finance major research centers for industry-academic research in priority fields. University-based technical extension centers disseminate state-of-the-art development throughout the industry. Research grants to faculty and institutions stimulate research interest and attract faculty to areas selected for priority development in the State. Funds are also available to finance new facilities for new technology programs in scientific and technological fields.

Last year a $90 million bond issue was passed to implement the recommendations of the Commission. The Commission's operating budget, established especially to stimulate research, is $16 million for the 1985–86 fiscal year.

What has been accomplished or provided for thus far?

A $24 million Center for Advanced Biotechnology will be constructed for Rutgers University and the University of Medicine and Denistry of New Jersey. Partial capital support will be provided towards Princeton University's $43 million biotechnology program. An additional $11 million will finance construction at the Waksman Institute of Rutgers and at the University of Medicine and Denistry of New Jersey.

New Jersey Institute of Technology will house a new Cooperative Research Center for Hazardous and Toxic Waste Management. The center is also supported by the National Science Foundation. Industrial company members, currently 12, contribute research guidance and $30,000 each to annual operating needs.

A Center for Ceramics Research has been established at Rutgers with support from the National Science Foundation. The Center enjoys over $1 million in industrial support through affiliate fees of $30,000 from each of 32 companies. Under consideration is the development of a second wing for research in fiber optic materials.

Rutgers University's Cook College will house a Center for Advanced Food Technology. Food processing is a $6 billion industry in New Jersey.

The Commission also has made grants in the areas of telematics, surface modification technology, and computer-aided manufacturing. New areas under study are fisheries development and aquaculture.

New Jersey has been selected as a national site for a supercomputer facility. Commission funding helped sway the decision New Jersey's way. The State funding will lend the supercomputer to New Jersey's research universities.

Two computer-integrated facilities—one in South Jersey and one in Newark—will be established jointly by NJIT and the State's community college. The centers will provide research and training in the application of robotics to the manufacturing process.

New educational and training programs have been established throughout the State's higher education system in such fields as laser optics, computer-aided design, software development, and robotics. Industry has been an active partner in program development.

New Jersey's efforts are ambitious and expensive. We believe that a stronger higher education systems serves New Jersey's residents who seek collegiate education in the State's institutions.

We believe, too, that strengthening the higher education system's capacity for teaching and research in science and technology contributes significantly to the State's economy, to employment and the economic well-being of all of our residents. Through each program in the Governor's science and technology efforts and the college grant program, New Jersey's research institutions are better able to contribute to national needs and national goals in science and technology.

New Jersey efforts are no different from the efforts of many States across the Nation. States support the research universities in the public sector and, in many States, in the private sector as well.

Special State efforts in science and technology are also common. Through such efforts, States finance initiatives that are also properly the responsibility of the Federal Government.

Where is the Federal Government in these initiatives?

Federal financing of research through the National Science Foundation, the National Endowments, and Federal departments related directly to applied research needs—Federal efforts in these areas have been adequate, if not substantial.

Even so, the States have had to shoulder at least two burdens that deserve Federal help because they are primarily national rather than State priorities.

While States have maintained the intellectual and technological infrastructure for graduate education in the sciences, engineering and related technologies, they do not, should not and cannot finance fellowship for students who enroll in such studies.

Doctoral students in all disciplines serve a national need; they are highly mobile individuals who often leave a State upon completion of doctoral studies. This support in doctoral studies clearly is a Federal responsibility and not a State responsibility. The Federal Government has been derelict in this area.

National graduate fellowships, awarded competitively, will assure that the most talented young people will pursue careers in basic and applied research. Now many of the best students are drawn to study in business, law, engineering and other professions where high rewards are coupled with less costly academic preparation.

Our doctoral programs in science and engineering enjoy heavy enrollments of foreign students who constitute a majority of students at our public institutions.

Where is the next generation of American research scientists? They are not at our universities in sufficient numbers today.

The States cannot afford to pay for all of the costly research facilities and state-of-the-art equipment needed in today's research and instructional programs. The States do shoulder a large share of the costs. That they cannot come near to doing the whole job is reflected in the higher dependence on obsolete, poorly maintained and inadequate equipment.

We have come to be dependent on private industry for donations of obsolete equipment. The States need Federal help to maintain up-to-date facilities for teaching and research.

The New Jersey unemployment rate is 6.2 percent, below the national average. It is low because our State has created a climate supportive to emergent industries. New university/industry research collaboration can spinoff new companies, new industries, new jobs. The new jobs replace those lost in the declining blue-collar industries.

Our unemployment rate of 6.2 percent is too high. In part, it is so high because vacant positions go begging while the unemployed and underemployed are not qualified to fill them.

We are determined to keep the economy growing by stimulating applied research and entrepreneurship. We are equally determined to keep the economy growing by improved technological literacy among all potential employees in all of the States, urban as well as surburban communities.

We want a renewed Federal effort in support of basic research to complement the new State initiatives.

Thank you very much.

[The prepared statement of Dr. Hollander follows:]

NEW JERSEY'S SCIENCE AND TECHNOLOGY INITIATIVE

TESTIMONY OF T. EDWARD HOLLANDER, CHANCELLOR
OF HIGHER EDUCATION, NEW JERSEY

TO THE U.S. HOUSE OF REPRESENTATIVES SUB-COMMITTEE
ON SCIENCE AND TECHNOLOGY POLICY

MARCH 21, 1985
(DETAILED REPORT ATTACHED)

Higher education has contributed to national science policy by building a basic research capability upon an intellectual base rooted in the liberal western tradition. Future progress rests upon stimulating the graduate and research capabilities of America's universities as a national policy. One means to achieve this end is a new collaboration between higher education, the state, the federal government and industry.

My purpose here is to call for a renewal of the public role in furtherance of science education at all levels, in furtherance graduate and research capabilities in the sciences and applied sciences and in the stimulation of the higher education-industry partnership.

Using my own state, New Jersey, as illustration, I will report on how one state has responded to the withering away of national commitment to the infrastructure of higher education. Subsequently, I shall argue for a renewed federal commitment to complement state efforts.

In New Jersey, Governor Kean is determined to make higher education more entrepreneural. While protecting institutional base budgets from enrollment erosion, he has proposed funding new initiatives on a "challenge grant" basis, that is, requiring that public and independent institutions compete for new funds. Additionally, the governor has secured passage of a $90 million bond issue and has directed annual appropriations towards economic development through support of basic and applied research at New Jersey's universities. Still further, he has supported financing of improvement in science and mathematics education at all levels of schooling in the state.

A long-standing and major state commitment to science and technology is New Jersey's support of the "intellectual and technological" infrastructure of research oriented instititutions. For example, almost half of the state's total appropriation for higher education, or $300 million annually, supports the state's three public universities, Rutgers, the University of Medicine and Dentistry of New Jersey and the New Jersey Institute of Technology. These funds include support for research facilities, laboratories and libraries. They permit reduced faculty teaching loads to support research, basic and applied. They support special highly paid distinguished research scientists and humanists. The state finances the graduate programs that educate the nation's instructors and research scientists. Private funds have built and maintained similar efforts at Princeton University and Stevens Institute of Technology.

The point is that this nation's university based research capacity has been built and is maintained in large measure by state government.

New in New Jersey this year is Governor Kean's challenge to New Jersey's higher education institutions to reach for national status through improved quality. The state is helping Rutgers University to increase its operating budget by $60 million annually (over a three-year period). The new funds will strengthen the University's research capability by financing the recruitment of world-class scholars, young faculty members, and graduate assistants. New funds will enhance the library and finance computer acquisitions. A similar program has been established for the state's technological university, the New Jersey Institute of Technology.

Complementary "challenge grant" programs have been established for all of the state's teaching institutions. A challenge grant fund of up to $30 million (over three years) will strengthen the nine state colleges. A fund that could reach over $25 million is dedicated to providing competitive grants for technological equipment acquisitions and computer applications at all public and private institutions. Over three million dollars has already been provided to retrain primary and secondary school teachers of mathematics and science. New teacher training requirments emphasize liberal education with a required major in a field of study in the sciences, social sciences or the humanities. Remedial education is required to be provided to every freshman admitted to a public college who is deficient in verbal or mathematical ability. Competitive challenge grant funds also are available to strengthen education in the humanities, foreign languages, global education, and the improvement of teaching.

Merit-based scholarships for undergraduates and state graduate fellowships tell students we care about scholarship and intellectual development. All of these efforts and others are designed to strengthen quality in undergraduate teaching, with emphasis in science and technology.

These efforts are complemented by the new funding of science and technology as recommended by the report of the Commission on Science and Technology. Established by Executive Order in 1982 on my recommendation and the recommendation of several college presidents, the Commission proposed a program of economic development through new partnerships between graduate research institutions.

The Commission, after an eighteen month study, proposed a program for economic development using the state's research universities. Peer review teams identify fields of priority development in the state and select institutions best able to undertake collaborative research with industry. State funding is contingent upon matching industry funds for research activity. State capital funds finance major reseach centers for industry-academic research in priority fields. University-based technical extension centers disseminate state-of-the-art development throughout the industry. Research grants to faculty and institutions stimulate research interest and attract faculty to areas selected for priority development in the state. Funds are also available to finance new facilities for new teaching programs in scientific and technological fields.

Last year a $90 million bond issue was passed to implement the recommendations of the Commission. The Commission's operating budget established especially to stimulate research is $15 million for the 1985-86 fiscal year. What has been accomplished or provided for thus far?

-- A $24 million Center for Advanced Biotechnology will be constructed for Rutgers University and the University of Medicine and Dentistry of New Jersey. Partial capital support will be provided towards Princeton University's $43 million biotechnology program. An additional $11 million will finance construction at the Waksman Institute of Rutgers and at the University of Medicine and Dentistry of New Jersey.

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-- The Commission also has made grants in the areas of telematics, surface modification technology, and computer aided manufacturing. New areas under study are fisheries development and aquaculture.
-- New Jersey has been selected as a national site for a supercomputer facility. Commission funding helped sway the decision New Jersey's way. The state funding will lend the supercomputer to New Jersey's research universities.
-- Two computer integrated facilities--one in South Jersey and one in Newark--will be established jointly by NJIT and the state's community colleges. The centers will provide research and training in the application of robotics to the manufacturing processes.
-- New educational and training programs have been established throughout the state's higher education system in such fields as laser optics, computer aided design, software development and robotics. Industry has been an active partner in program development.

New Jersey's efforts are ambitious and expensive. We believe that a strong higher education system serves New Jersey's residents who seek collegiate education in the state's institutions. We believe, too, that strengthening the higher education systems capacity for teaching and research in science and technology contributes significantly to the state's economy, to employment and the economic well-being of all of our residents. Through each program in the Governor's science and technology efforts and the challenge grant program, New Jersey's research institutions are better able to contribute to national needs and national goals in science and technology.

New Jersey efforts are no different from the efforts of many states across the nation. States support the research universities in the public sector and, in many states, in the private sector as well. Special state efforts in science and technology are also common. Through such efforts, states finance initiatives that are also properly the responsibility of the federal government.

Where in the federal government are these initiatives? Federal financing of research through the National Science Foundation, the National Endowments, and federal departments related directly to applied research needs. Federal efforts in these areas have been adequate, if not substantial. Even so, the states have had to shoulder at least two burdens that deserve federal help because they are primarily national rather than state priorities.

While states have maintained the "intellectual and technological" infrastructure for graduate education in the sciences, engineering and related technologies, they do not, should not and cannot finance fellowship for students who enroll in such studies. Doctoral students in all disciplines serve a national need; they are highly mobile individuals who often leave a state upon completion of doctoral studies. This support in doctoral studies clearly is a federal responsibility and not a state responsibility. The federal government has been derelict in this area. National graduate fellowships, awarded competitively, will assure that the most talented young people will pursue careers in basic and applied research. Now many of the best students are drawn to study in business, law, engineering and other professions where high rewards are coupled with less costly academic preparation. Our doctoral programs in science and engineering enjoy heavy enrollments of foreign students who constitute a majority of students at our public institutions. Where is the next generation of American research scientists? They are not at our universities in sufficient numbers today.

The states cannot afford to pay for all of the costly research facilities and state-of-the-art equipment needed in today's research and instructional programs. The states do shoulder a large share of the costs. That they cannot come near to doing the whole job is reflected in the higher dependence on obsolete, poorly maintained and inadequate equipment. We have come to be dependent on private industry for donations of obsolete equipment. The states need federal help to maintain up-to-date facilities for teaching and research.

The New Jersey unemployment rate is 6.2%, below the national average. It is low because our state has created a climate supportive to emergent industries. New university-industry research collaboration can spin-off new companies, new industries, new jobs. The new jobs replace those lost in the declining blue-collar industries.

Our unemployment rate of 6.2% is too high. In part, it is so high because vacant positions go begging while the unemployed and underemployed are not qualified to fill them.

We are determined both to keep the economy growing by stimulating applied research and entrepreneurship. We are equally determined to keep the economy growing by improved technological literacy among all potential employees in all of the states, urban as well as suburban communities. We want a renewed federal effort in support of basic research to complement the new state initiatives.

Attachment to
Testimony

Dr. T. Edward Hollander
Chancellor of Higher Education
State of New Jersey

United States Congress
Washington, D.C.
May 21, 1985

Report to the U.S. House of Representatives Sub-Committee on Science and Technology Policy
(Appendix to Oral Statement)

Our nation and most of the developed world are undergoing a fundamental transition from industrial economies to information/knowledge-based economies. It is a transition as profoundly altering as the Great Depression of the 1930s, when the United States emerged fully from its agricultural past to its industrial present. Whether we call it a "megatrend," to use John Naisbitt's popular word, or the more conventional phrase of economists, that of "structural change," it is real; it is here now, and it is no longer an idea to be planned for the future.

Change will result in shifts: from new manufactured products to new services; from a workforce which was predominantly blue collar to one that is white collar; and from heavy, rigid technologies to automated, flexible technologies. The most obvious example of the latter is the powerful new generation of microcomputers, which are highly portable and adaptable to tommorrow's software developments. For individuals, the shift will be from an emphasis on manual dexterity -- or running a machine-to cognitive skill -- understanding a technology. Each change underscores a basic characteristic of our knowledge-based society.

These changes promise a new and vital role for higher education. It is in the higher education classroom and laboratory -- at our two-year and four-year colleges and universities -- that training for entry-level jobs will occur. Educators must employ greater rigor in determining what our students
-- 20 million students each year -- study and learn. As we ensure the development of "computer literacy," along with other forms of technical training, we must also cultivate older, more basic literacies essential to educated men and women.

At the same time, those who hire the graduates of higher education -- business and industry -- must seek and be encouraged to collaborate in the development of instructional needs and personnel exchanges. The relationship between these two sectors, higher education and industry, is no longer sequential; it will become increasingly interactive and lifelong. Programs of customized training, which represent a successful collaboration of industry and community colleges, are but one example of this interaction. There is a need for continuing education to combat obsolescence in the face of changing knowledge. Higher Education has much to learn -- and offer in return -- from the experiences of corporate training programs in this area, with their effective use of telecourses and videocoupling.

To ignore this challenge to both partners is to risk a greater consequence to our society -- to enter the 1990s, when labor shortages are predicted, with vast numbers of our countrymen unemployed, underemployed, or, worse still, unemployable.

It is my purpose to call for a renewal of the public role as part of these partnerships. Governments, both federal and state, are kidding themselves if they expect business and industry to support, in any meaningful way, the costs of basic scientific research and instruction.

Beyond this recognition, it is essential to make a further distinction between the province of the states and the federal government in the development of national science and technology policies. It is both unfair and unrealistic to expect individual states to shoulder the burden of the nation, if the federal government proposes to retreat from its traditional responsibilities. This is especially true in the sponsorship of basic research, where the budgets of the National Science Foundation, the National Institutes of Health, and the mission agencies must be advanced beyond maintenance levels. Only the federal government can command the resources necessary to support effectively basic research. Despite the exigencies of the deficit, if the federal government pursues policies of under-funding higher education and research, I doubt that the new partnership between higher education and industry will reach its full potential -- and the difference will not be trivial.

By the same token, we should not exempt state governments from this support problem. My report is offered as a representative of one of the nation's largest state systems of higher education. I believe that, during the first four years of the current national administration, the states, and in particular New Jersey (the state I know best), have responded well to the changing locus of higher education support. We are providing the support for what I would call the "intellectual and technological infrastructure." This represents funding for the financing of the facilities and the equipment for research and instruction, as well as the salaries for top-flight faculty and technical personnel.

Using my own state, New Jersey, as my illustration, I hope to portray the magnitude of this support. This funding is occurring both through the on-going and expanded efforts of the New Jersey Department of Higher Education and through a special science and technology initiative of our Governor, which recently became a permanent Commission on Science and Technology. I shall describe both sources. I also intend to offer some general observations on the role of the states in science and technology, expanding on my previous point about what the states can and cannot do.

The State appropriation for higher education support in New Jersey is approaching $650 million, for the coming fiscal year. Of this amount, nearly 50%,or $298,316,000, is appropriated to support New Jersey's three public doctoral-level institutions of higher education (i.e., Rutgers University, New Jersey Institute of Technology, and the University of Medicine and Dentistry of New Jersey). These amounts constitute base support. The Department receives another $40 million for debt service, to meet the capital construction costs of higher education facilities. These construction obligations are distinct from the $90 million science and technology bond which the voters of New Jersey overwhelmingly approved, in November 1984, for the construction of new research laboratories and centers and instructional facilities.

Beyond these base level and construction obligations, the Governor has recommended special initiatives for both instructional and research improvements in higher education. These initiatives include an $8 million "challenge grant for excellence" to Rutgers University, to be expended as follows:

(1)	World - class scholars	$1,200,000
(2)	Junior faculty	989,000
(3)	Graduate assistantships	744,000
(4)	Faculty support	2,267,000
(5)	Libraries	500,000
(6)	Computers	1,300,000
(7)	Academic facilities	1,000,000
		$8,000,000

The New Jersey Institute of Technology will receive $3.7 million for similar purposes, broken down as follows:

(1)	Instructional equipment	$3,000,000
(2)	Faculty chairs	600,000
(3)	Computer networking	100,000
		$3,700,000

With a "technology and computers fund" of nearly $7.6 million, the Department of Higher Education will undertake programs to modernize scientific and engineering equipment, facilities and curricula, and to integrate computers into the college curriculum. In addition, programs will upgrade the technical knowledge and skills of teachers and college faculty contribute to the technological literacy of all New Jersey citizens.

(1)	Technical/engineering education grants	$2,873,000
(2)	South Jersey Regional CIM Center	300,000
(3)	Math/science/computer science teaching initiative	1,000,000
(4)	Computers in curricula	2,919,000
(5)	Information-age initiative	500,000
		$7,592,000

These several initiatives combine to form a major instructional improvement program in New Jersey, with primary emphasis on science and technology. Improvements in research are being stimulated by the Commission on Science and Technology, especially where these efforts support New Jersey's high technology economic development strategy.

The Governor's Commission on Science and Technology was established by Executive Order in July 1982, to create a blueprint and action plan for the economic development of New Jersey, in a post-smokestack industrial era. This program of economic development emphasizes the applications of science and technology, through new partnerships between graduate research academic institutions and industry.

The Commission has identified the components of a technology development strategy that builds on New Jersey's industrial and academic strengths. The strategy requires that we make investments in ideas, enterprise and people. It also requires coordinated efforts by both public and private sectors. Finally, it requires a long-term commitment.

One of the Commission's most important recommendations is that the infrastructure for New Jersey's science and technology initiative -- the laboratories and research centers -- be provided through a major capital improvement program. These improvements will be accelerated now that the voters have approved the referendum for the $90 million "Jobs, Science and Technology Bond." Details on this bond issue are provided in a later section of this report.

The Commission's funding programs emphasize the technology fields that have been designated as "priority" (materials science, biotechnology, hazardous substance management, food technology, and telematics) for New Jersey's development program. Moreover, these grants have been received, in the main, by those institutions housing Advanced Technology Centers in these priority fields or, in the case of Stevens Institute of Technology, a Technology Extension Center in polymer processing.

The program expenditures of the Commission for the current fiscal year (FY 1985) amount to more than $9 million, which provide operational funding for the Centers and new categories of support, such as Innovation Partnerships (matching research grants for selected scientific and engineering projects). In addition to broader ranges of support, this appropriation continues to fund the priority technology fields and add start-up support in second-stage fields, such as materials handling and fisheries development.

The Science and Technology Budget for FY 1986 requests funds totalling $16 million for new and on-going programs and administrative expenses.

These allocations are commensurate with the levels of funding recommended by the expert peer review panels which the Commission engaged to evaluate the relative strengths of New Jersey's science and technology initiatives. Especially significant is the funding for new areas of science and technology research. Such funds are vital to the Commission's plan of diversifying high technology opportunities for the state.

There are several sources of non-State revenue which will strengthen the research programs of New Jersey's higher education institutions, principally as a consequence of the Commission's matching grant requirements as applied to appropriated funds. The most significant sources are from the federal government and industry.

The Commission's matching guidelines currently require that each State-funded dollar for "research and operating" support of New Jersey's high technology initiative be equally matched from non-State sources (generally, industry and the federal government). Under the category of "capital equipment," with the understanding that corporate giving patterns have proven to be much more conservative, the Commission is requiring that one-third of the total cost be represented by matching funds from non-State sources.

The Commission currently projects industrial and federal matching funds to reach $23 million, in FY 1986. The attainment of this multiplier effect on appropriations is an important measurement of the payback of New Jersey's investment in science and technology development, as one important aspect of the State's overall program of economic development and new revenue generation.

FY 1986 will see the initiation of several important new programs by the Commission. Among these new programs is the establishment of a nationally-based advanced scientific supercomputer center in New Jersey; a research center to investigate fiber optical materials; an industrially co-sponsored plastics recycling research program; and a private industry challenge grant organized by the American Electronics Association, with the anticipation of State matching, to fund graduate education, faculty development, and instructional equipment in electrical engineering and computer science.

These and other initiatives will be overseen by a permanent New Jersey Commission on Science and Technology, signed into law on April 5, 1985, replacing the temporary Governor's Commission.

As I indicated earlier, the technology infrastructure for many of these projects will occur through the $90 million "Jobs, Science and Technology Bond." These improvements will proceed according to the following general expenditure plan:

A. Advanced Technology Centers

Major construction projects are proposed on sites at or near New Jersey's graduate research institutions of higher education. Construction, which could include the acquisition of real property, principally would occur at Rutgers, the New Jersey Institute of Technology (NJIT), and the University of Medicine and Dentistry of New Jersey (UMDNJ), although some capital improvements might qualify at private higher education institutions such as, Stevens Institute of Technology and Princeton. (For planning purposes, a construction cost of $200, per square foot, has been used to arrive at these budget estimates.)

(1) Biotechnology. The Advanced Technology Center for Biotechnology, for which the most significant capital improvements were recommended by the Commission on Science and Technology, actually refers to five interrelated projects, which together total $40 million. The core facility, to be known as the New Jersey Center for Advanced Biotechnology and Medicine, would be new construction located on the adjoining campuses of Rutgers and UMDNJ in Piscataway. It is here that the major research projects of Rutgers and UMDNJ jointly would be conducted and where senior staff, including the director, and technical support would be housed. The capital cost of this project are $23,600,000.

This core facility would be backed-up by three satellite facilities, all within close proximity to the new Center. First, a fermentation and biomaterials separation facility would be added to the current Waksman Institute for Molecular Biology, at a total capital cost of $4 million. Second, the clinical research facility for the Center would be housed at the Middlesex General-University Hospital, in New Brunswick, where renovations are proposed at $4.6 million. Third, existing laboratories at both Rutgers and UMDNJ would be integrated into the research complex of the core facility, with building modification and new equipment costs targeted at $3 million.

Finally, the Science and Technology Commission has recommended, and the presidents of both Rutgers and UMDNJ also have called for, a contribution of $5 million to the capital facilities in molecular biology, proposed for construction at Princeton. This amount represents only a small portion of the $46 million investment Princeton is making in molecular biology, but it would signify a genuine endorsement by New Jersey of the new spirit of cooperation in this field, among Rutgers, UMDNJ, and Princeton, and help to draw these three institutions closer together for combined research. Developing a world-class center in biotechnology in New Jersey, with all its component parts, requires serious attention to the advantages of this three-way relationship.

(2) Hazardous and Toxic Substance Management. Although without a central facility, the Cooperative Research Center for Hazardous and Toxic Waste began its research activities in 1984. The Center is supported by the Commission, the National Science Foundation, and industrial company members (currently twelve), each contributing research guidance and an annual fee of $30,000 toward research sponsorship.

The research and public policy programs of the Center, which will emphasize such areas as incineration, biological and chemical treatment, and physical treatment, will be assets to both New Jersey and the nation. They will bring university-level research to bear on such problems as toxic waste clean-up, as well as apply these fundings to such economic growth areas as resource recovery.

The Center will receive a core facility, both to meet this potential and to draw together the five graduate institutions of higher education -- led by NJIT -- that have formed the research consortium to do the work. The Commission has recommended that $7 million of the bond issue be assigned to this facility, with new construction to occur in Newark, at the campus of NJIT. Additional funds will be provided for land acquisition.

(3) Advanced Ceramics. The Center for Ceramics Research (CCR) at Rutgers, performing lead-edge research in one of the so-called new materials of the future, is fast approaching world-class status -- both in the independent judgment of leading faculty from MIT and as assessed recently by High Technology Magazine. The Center has an industrial membership of thirty-two companies, with its annual affiliates fee to $30,000, all of which translate into an industrially-sponsored research program of nearly $1 million, per year. CCR also is supported by the National Science Foundation.

The recommendations of the Commission are designed to ensure that CCR attains this world-class standing and generates benefits of primary inportance to New Jersey. The latter will occur through a further enhancement of CCR's research program emphasizing technology transfers to New Jersey's small and medium-size industrial ceramics companies and through the provision of a core facility to CCR on the Busch Campus of Rutgers. Currently, CCR operates from borrowed (and out grown) space at the Engineering School.

The Commission has recommended $9 million for this core facility. In addition, preliminary discussions have been held on the development of a "second wing" of this facility, for the research and prototype development of optical fibers -- the materials over which fiber optic network transmissions occur. CCR has nascent strengths in this area that many companies and the U.S. government wish to encourage.

(4) Food Technology. Food technology encompasses the study of chemical, biological, and engineering aspects of food and food processing, packaging, and storing. The food industry is an important part of New Jersey's economic base; food processing represents annual shipments of over $6 billion in New Jersey. At the same time, the state has experienced a loss of employment in the overall food industry, with the relocation of production centers.

The proposed Center for Advanced Food Technology, with a capital requirement of $6 million, will strengthen New Jersey's research and economic base in this industry by providing new food products and developing more efficient and economical food processing and related techniques. The nucleus of this Center will be formed around the Food Science Department at Cook College/Rutgers. The core facility, to be located on the Cook campus, will draw together the strengths of nearly a dozen academic departments, including Biochemistry, Chemistry, Nutrition, Plant Physiology, Mechanical Engineering, Chemical Engineering, and Materials Science. In addition to strengthening joint research and development programs, this facility will include a pilot plant designed to bridge the technical gap between laboratory research and commercialization. Given the cross-disciplinary, commercial orientation of the Center, we anticipate that it will help to spin-off new businesses in such areas as ingredient supplies, chemical and packaging supplies, processing and sensory equipment and instrumentation, warehousing, and waste disposal.

(5) Stage Two Needs. Although the Commission was not able to ascertain additional needs with the same finality as those identified above, its report emphasizes that there will be other capital requirements over the next several years. We already have mentioned the optical fiber materials area as a possible "second wing" of the Center for Ceramics Research. Another academic area where we anticipate requirements for

capital improvements is the field of telematics -- representing the growing confluence of computer technologies and telecommunication. A third area, under the general heading of materials science, is surface modification technology. We believe there will be other needs, as well.

For this reason, the Science and Technology Commission strongly urged that sufficient funding -- $15 million -- be available to permit timely forward movement in these areas as soon as their importance is confirmed and their requirements more precisely identified. These determinations will be the responsibility of the new permanent Commission.

B. Undergraduate Technical and Engineering Facilities

To ensure the instructional improvements that are needed for a technology-trained workforce in New Jersey, the Commission recommended that substantial capital funds -- $23 million -- be provided to maintain high quality science and technology education at the public four-year and community colleges, as well as at many independent institutions of higher education. These funds will be applied to the construction and improvement of instructional laboratories, computer and educational facilities, and building space for technical equipment installations.

Projects to be funded from this portion of the bond issue will be for major capital expenditures valued at more than $250,000, and with an extended use-life expectancy. These expenditures will differentiate themselves by dollar size and nature from current technology initiative grant programs to higher education institutions and especially from Chapter 12 projects that fund the county colleges. A competitive grant process, within each sector, will be used. All projects drawn from this $23 million fund will receive the approval of the Board of Higher Education.

C. Other Technology Initiatives

(1) South Jersey Engineering Facilities. At present, there are no facilities for undergraduate or continuing professional engineering training in South Jersey. There is an increasing need for such programs with the growth of technology-based businesses in this area of the State. The bond sets aside $3 million for construction of needed facilities as part of the establishment of a new West Campus for Burlington County College. The last two years of undergraduate engineering training and continuing professional education for the industrial community will be provided here. The program will be a cooperative venture between Burlington County College and the New Jersey Institute of Technology.

(2) Computer Assisted Design/Computer Assisted Manufacturing Center. A regional county college-based training center for computer assisted design and computer assisted manufacturing (CAD/CAM) will be established with $4 million of the bond proceeds. This center will focus on robotics technologies and would be used by the community colleges in South Jersey for technician training. A consortium of county colleges will operate the center.

(3) Other projects, to be designated. The State Board of Higher Education will retain control over $3 million. These funds will be used to meet future needs for construction and renovation.

Summary Observations

High technology development is currently of great concern to many state governments. Various measures exist to promote advanced scientific and technological growth at the state level. These include supporting technological training programs and removing barriers to business development which are imposed by individual states. Some of the most important activities which will promote the growth of advanced technological industries cannot, however, be undertaken at the state level. These include the removal of tariffs on American goods in foreign countries, and the reform of federal regulations concerning business taxation and investment. In the following discussion, the focus is on those areas which individual states can and cannot affect to promote high technology development.

What State Government Can Do: Education And Economic Development

State governments can play a significant role in high technology development through their involvement in education and economic development. Specific measures which enhance high technology development are outlined below.

A. Industry - Education Alliance: State governments can seek to increase and strengthen collaboration in research and instructional support between their industries and academic institutions, by encouraging

1. the development of joint appointments and improved salary packages to enhance the recruitment and retention of engineering and computer science faculty, especially of young faculty;

2. the development of joint and third-party support mechanisms to encourage specialized graduate courses and research at the cutting edge of science and technology, jointly conducted research and development and exchanges of personnel;

3. technology transfers, especially to small and medium-sized industrial enterprises, to increase the actual implementation of high technology research and development; and

4. the development of inter-institutional "centers of excellence," with industry participation and with a precise focus on mission (e.g., telecommunications, biogenetics), since a "critical mass" of faculty and facilities, supporting infrastructure, and economic resources is viewed as essential to successful implementation.

B. Engineering Education and Training: Recognizing the high level of responsibility which states must accept for the health of engineering education, state government can identify ways to expand the applied scientific, technical, engineering and computer science capabilities of their higher education institutions, including

1. aggressively recruiting promising undergraduates for graduate programs in fields like engineering and computer science, with support from both publicly-sponsored and industry-sponsored stipends (based upon work commitments for sponsored students);

2. increasing higher education's capacity to train a more technology-oriented work force, especially through associate degree programs and programs of customized training;

3. providing greater access to professional engineering and technical careers for students who traditionally have entered scientific fields in limited numbers (i.e., women and minorities);

4. expanding continuing education opportunities, particularly at the professional and technical levels, to overcome job skill obsolescence; and

5. a re-examination of those policies which may preclude making the pay of engineering faculty competitive, including the removal of disincentives to entrepreneurship.

C. Equipment and Facilities: State government can seek to overcome any equipment or facility deficiencies at their institutions of higher education, including

1. improvement and upgrading of the research and instructional equipment at these institutions, through both equipment donations from industry and industry-government matching support programs; and

2. in combination with other capital needs for higher education, the authorization of general revenue "science and technology" bond issues to finance laboratory improvements and related areas of deferred maintenance.

D. Research/Industrial Parks: State government can also investigate the feasibility of stimulating public/private research and industrial parks, including the provision of low cost financing from the State's economic development agencies for the construction of such parks in targeted urban areas capable of benefitting from close interaction with academic research centers.

E. The Economic and Working Environment: State governments can assist their agencies by helping to investigate the economic obstacles to and incentives for high technology development, including

1. the usefulness of revising the corporate tax code, and especially the provision of loss carry-overs, to encourage capital formation and new business investment;

2. the viability and potential use of differential tax rates, and tax abatements, as well as easements on the availability of loans, industrial bonds and grants, as incentives to high technology industrial start-ups;

3. government regulations on business operations, including those pertaining to environmental protection, to determine whether obstacles to economic development can be alleviated;

4. the participation of financial institutions, especially those vertically-integrated institutions that can assist high technology development in all its phases, from research to commercialization; and

F. Scientific and Technological Literacy: State government can identify programs to improve science education and technological and computer literacy at all educational levels, such as

1. the feasibility of establishing science and mathematics teacher training institutes at colleges and universities to meet shortages of qualified teachers in the secondary schools in these fields;

2. the encouragement of programs which serve to "demystify" science and technology as subject-areas beyond everyday comprehension;

3. the development of special high school programs to increase the pool of qualified minority group students who concentrate on science and mathematics as preparation for higher education and relevant careers; and

4. the development of enriched undergraduate programs for economically and educationally disadvantaged students to increase entry and eventual employment in technological fields.

What state goverments cannot do: improve export market conditions, reform federal tax and environmental regulations.

Several of the most important measures which need to be taken in order to promote high technology growth in the United States cannot be carried out at the state level. These are in addition to the fundamental role of the federal government in sponsoring basic research, as discussed earlier. Among these measures are the following:

A. Improving the market conditions abroad for high technology products. Many foreign countries have extremely high tariffs against imported goods which are produced using advanced technology. These countries claim to be "protecting" domestic producers of the same goods. The federal government can lobby for greater free trade in products resulting from sophisticated technological processes. State governments have no authority to conduct foreign affairs, so they can do little to improve this situation.

B. Improving the business climate by lowering corporate taxes and eliminating unnecessary regulation of high technology industries. State governments are limited in the degree to which they can foster high technology development by corporate taxes and regulations imposed at the federal level. State governments can press the federal government for change, but there is nothing they can do legislatively to ameliorate the situation.

C. Controlling migration of the labor force. The manufacturing side of high technology development involves blue-collar workers engaged in running factories in which sophisticited products are made. High technology firms are eager to locate in states with large numbers of skilled and unskilled laborers. Other states may suffer a loss of workers, if more attractive positions exist elsewhere in the country. There may be little that state governments can do to prevent these migrations.

What the federal government can do: help to modernize on-campus facilities and equipment for basic research.

This report describes major initiatives occurring at the state level, and in particular in New Jersey, aimed at improvements in science and technology. Joining forces with local industries and major corporations, the states are providing leadership in the education of students and in the formation of industrial policies for economic development and new job creation. For these efforts and policies fully to succeed, however, we need the active participation of the federal government, especially to help meet the considerable costs of the infrastructure for basic science and research.

The days are past when we should expect the federal government to provide the sole support for these needs. Support from the federal government must be matched by the states, the recipient higher education institutions, and industry. My report indicates that these sources are both available and actively engaged in making improvements. What also must occur is leadership from Washington.

While states have maintained the "intellectual and technological" infrastructure for graduate education in the sciences, engineering and related technologies, they do not, should not and cannot finance fellowship for students who enroll in such studies. Doctoral students in all disciplines serve a national need; they are highly mobile individuals who often leave a state upon completion of doctoral studies. This support in doctoral studies clearly is a federal responsibility and not a state of responsibility. The federal government has been derelict in this area. National graduate fellowships, awarded competitively, will assure that the most talented young people will pursue careers in basic and applied research.

I am calling on this committee to support legislation for a major laboratory modernization program for on-campus facilities and equipment in basic research. This legislation should seek increased appropriations for NSF, NIH, and the mission agencies, with the costs shared fairly by higher education, industry, and states. It is only in this way that we can hope to remove the twenty years of neglect faced by these laboratory facilities and restore them as the driving engines of our science and technology machinery.

There should be no underestimation of the magnitude of this problem. Several years ago, my Department analyzed the costs to remedy the serious disrepair of research equipment, alone, at our major academic institutions. The result was estimated, conservatively, as a $40 million problem in New Jersey, and a $1 billion problem, nationwide. Our Commission on Science and Technology responded quickly, but within the limits of the State's resources, by recommending that more than $4 million be spent for these improvements in New Jersey, during FY 1984. In subsequent fiscal years, we have raised this level to the $6-7 million range, annually.

We have made improvements but the eradication of this equipment problem, and the construction of the facilities to house these instruments, is long-term. The disrepair continues, and it is only with a major infusion of federal support that we will ever be able to rise above these maintenance levels. The national and international requirements of science and technology do not permit us to stay at maintenance levels. We must advance through growth and expansion.

DISCUSSION

Mr. **Brown**. I can assure you that is a very impressive statement and testimony to the leadership which New Jersey has given. I hope you are correct that the other States are doing as well.

Dr. **Hollander**. Some are.

Mr. **Brown**. Some are. But it would make me rest easier at night if I felt they were.

Mr. Lewis, do you have any questions?

Mr. **Lewis**. I have one, Mr. Chairman.

You are stating, Doctor, that you want renewed Federal effort in support of basic research. How do we compare to, say, the Soviet Union or to Japan in that area?

Dr. **Hollander**. I can't answer that question specifically. I believe we do very well.

Mr. **Lewis**. Do you feel that we provide more assistance for students, for doctoral theses than, say——

Dr. **Hollander**. I can't answer that question.

Mr. **Lewis**. How do you feel, then, we need to do more?

Dr. **Hollander**. Well, our efforts in New Jersey are essentially supporting applied research. There is a direct and tangible reward, if you like, to our taxpayers in that research.

The payoff is clear, and it is not too difficult, has not been too difficult, for us to persuade taxpayers to support investments in research in the universities where those investments in the taxpayers' minds are related to the creation of new jobs, a greater tax base.

We have greater difficulty arguing for support of basic research, more theoretically oriented research, which we do support indirectly in our support of the staffings at the universities and facilities at the universities. But that fundamentally is a Federal responsibility; it crosses State lines. It is of interest to the Nation, and our institutions participate in that effort, as do the major universities throughout the country.

But the Federal Government really has a responsibility to do for those institutions, in terms of basic research, what we in New Jersey are doing with taxpayer money for applied research.

Mr. **Lewis**. Do you feel that the Federal Government should also be involved in establishing chairs for various scholars in the State university systems?

Dr. **Hollander**. I would say that would be a lesser priority. I think that is more of a State responsibility than Federal responsibility.

I would define the priorities in the Federal responsibility as facility, maintaining equipment up to date, and national graduate fellowship programs in support of doctoral studies.

Mr. **Lewis**. Thank you.

Thank you, Mr. Chairman.

Mr. **Brown**. Dr. Hollander, I would like to explore with you just a little bit more the role of the Commission on Science and Technology which you have described in your statement.

I gather that that is ongoing?

Dr. **Hollander**. Yes.

Mr. **Brown**. A permanent commission?

Dr. **Hollander**. It will be continuing.

Mr. **Brown**. A continuing commission established how long ago?

Dr. **Hollander**. About 2 years ago.

Mr. **Brown**. And it has a separate operating budget, and were some of these or most of these initiatives that you have described recommended by this commission?

Dr. **Hollander**. Yes, they were. The Commission was staffed initially by the department, my department, the Department of Higher Education. It was comprised of university presidents as well as chief executive officers of major corporations in the State.

We set up a system of peer review to evaluate, first, where we thought the State would grow on the basis of pure and applied research and, two, where our universities really had a capability of making a contribution.

Where those two coincided, the Commission recommended major State funding of a Center for Advanced Technology in that area.

Where the Commission based on peer review felt that we needed capability in the area, the commission recommended funding of what we call innovative partnership. That is funding of research by faculty and encouraging industry to also fund research to build up a capability, hopefully, to lead to an advanced center for research in that area, and that has been done.

The third part of it, also recommended by peer groups, is a strategy for dissemination. That is to make the result of the research available not just to one or two companies, but the whole industry in the State, the service organization based at the university.

Mr. **Brown**. How would you categorize the degree of cooperation from your industries' CEO's; have they played a prominent role in developing the kind of cooperation you have described here?

Dr. **Hollander**. An important role; in fact, the most important role, in my judgment, was their identification of, if you like, world-class national capability, nationally recognized researchers in a number of fields where they had heretofore been skeptical of the research capability in the state outside of Princeton.

Their investment with the Commission led to their direct commitment of resources in support of some of the centers, but more important than that, their commitment of support for increased State financing of our higher education system. And that aspect, as a result of the Commission activity, benefited all the institutions in the State.

Mr. **Brown**. In other words, their support of the State's funding provided the political?

Dr. **Hollander**. They helped sell the bond issue. They also helped sell it under conditions which they recommended involving matching support, that is, requiring matching support in all the areas. That is built into all of our proposals.

Mr. **Brown**. How long do you anticipate, or is it possible to quantify this, that you will begin to see some measurable results in terms of economic impact, impact on the unemployment rate and so forth, from this kind of a comprehensive program?

Dr. **Hollander**. That is hard to say. It is going to come slowly at first, and hopefully faster later on. There has been some impact already. There have been a number of firms that located or will be spun off from research activities as a direct result of the Commission and other efforts of the university.

For example, one, a new pharmaceutical house was established by a university researcher at our medical school. The company has since gone public and that has brought research jobs into the State, and if the research is successful, possibly something beyond that.

We have got spinoffs that have greatly affected over a longer period. Even before this Commission, there has been collaboration between our universities and the pharmaceutical industry and chemical industry which are very strong in New Jersey. These have been more formalized with the centers, where collaborative research can take place.

I don't know how long it will take to spin off into new companies or new products or expansion based on patentable products from the research efforts. That is really hard to say. And I guess even if it isn't directly discernible, the impact indirectly on the State's economic environment and attitude toward the State on the part of new companies, I think, is considerable.

Mr. **Brown**. Well, I am very grateful to you for your testimony, Dr. Hollander. It has been a major contribution to the work of our task force, and we appreciate your being here this morning.

Dr. **Hollander**. Thank you for inviting me.

Mr. **Brown**. The task force will be adjourned.

[Whereupon, at 12:10 p.m., the task force recessed, to reconvene Wednesday, May 22, 1985, at 10 a.m.]

THE FEDERAL GOVERNMENT AND THE UNIVERSITY RESEARCH INFRASTRUCTURE

WEDNESDAY, MAY 22, 1985

House of Representatives,
Committee on Science and Technology,
Task Force on Science Policy,
Washington, DC.

The task force met, pursuant to recess, at 10:05 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the task force) presiding.

Mr. Fuqua. Today we continue hearings on the role of the Federal Government in supporting the research infrastructure of America's universities. Yesterday we heard from several members of the administration, a representative of the State governments, and the National Academy of Science.

Today we are privileged to hear from several of the major associations of research universities, from a representative from American industry, and from two individuals who can tell us about specialized aspects of funding and manpower issues affecting the research infrastructure.

These hearings before the task force will give us a sound basis for developing the recommendations we will have next year concerning this important issue. We hope to learn more about the fiscal issues which directly affect the maintenance of the research infrastructure and, based on what we have learned, we may wish to ask our witnesses some supplemental questions. We hope they will be able to continue to give the benefit of their experience in the coming months.

Our first witness this morning will be Dr. Oliver D. Hensley, chairman, Study Group on Research Personnel, Society of Research Administrators, and associate vice president for research, Texas Tech, Lubbock, Tx.

We will be pleased to hear from you at this time.

[A biographical sketch of Dr. Hensley follows:]

Dr. Oliver D. Hensley

Associate Vice President Texas Tech University.

Chairman of the Society of Research Administrators Study Group on Research Support Personnel.

	Years
Chemist, Drew Chemical Co.	10
Public schoolteacher	6
Research administrator, faculty member and principal investigator at University of Illinois	2

	Years
Southern Illinois University	6
Northeast Louisiana University	9
Texas Tech University	1

STATEMENT OF DR. OLIVER D. HENSLEY, CHAIRMAN, STUDY GROUP ON RESEARCH SUPPORT PERSONNEL, SOCIETY OF RESEARCH ADMINISTRATORS, AND ASSOCIATE VICE PRESIDENT FOR RESEARCH, TEXAS TECH, LUBBOCK, TX

Dr. **Hensley**. Mr. Chairman, members of the task force, I am Oliver Hensley, associate vice president for research at Texas Tech and chairman of the Society of Research Administrators' Study Group on Research Support Personnel.

I want to thank you for inviting me to testify about the significance of research support personnel to university research and about their impact on national and university research policy. I will want to emphasize the importance of reassessing both national and institutional policies and linking these others. The topic that I am talking about is most important to the maintenance of excellence of university research and to the continuing welfare of the Nation.

I have been studying research support personnel, one part of the infrastructure, for 5 years. It is difficult to give uniform data about them.

I will share with you some personal impressions about research support personnel and some interrelated modeling problems that exist with that particular group, and then point out some of the highlights of recent developments from a comprehensive SRA study of research support personnel.

First, I would like to talk about the significance of research support personnel to research. It is not understood by policymakers and, consequently, this group has been ignored in science policy.

Second, I believe that the exact size of the total research support personnel population is not presently known, but there are estimates that they number more than a half million and are the fastest growing group in academia.

Third, the present national cost of maintaining university research personnel is enormous. I believe that it is the biggest part of the university research budget and that their cost is increasing at an astounding rate.

Fourth, I believe that quality support services can be maintained with a strong congressional commitment to support this part of the infrastructure.

Fifth, the direct and indirect cost reimbursement mechanism associated with project funding is an adequate and a fair way of maintaining the infrastructure if policymakers will accept the fact that the full cost of research must be recovered for every project and if policymakers will update their personal perceptions and share formal models that keep pace with the changing times.

Sixth, I believe that a continuing comprehensive study can be made by research support personnel and other segments of the infrastructure if Congress, the National Science Foundation, and the professional associations such as SRA will arrange for and support the periodical exchange of timely information.

Your hearings are an excellent start in that direction. The Society of Research Administrators will respond by inviting one of your members to speak about the task force agenda at our national conference in St. Louis in October of 1985.

I would like to spend some time just highlighting the results of this comprehensive SRA study. The majority of my remarks will be included in the written presentation I have given to you. Time does not permit the full coverage of that, so I will just headline some of the more important findings.

The most important finding of the SRA study group was that this part of the infrastructure, the research support personnel, has grown so fast that it really has not been studied and it is completely undervalued because policymakers at the national level and in the institution really don't understand the significance of this particular group.

The SRA study group found that Federal agencies, university associations, and the professional societies have not valued research support personnel enough to distinguish them from other groups and then to study them. They also found out that there was a wide acknowledgment that research personnel are essential to the continued advancement of science, to the advancement of specific missions of postsecondary institutions, and to American technological leadership. Yet, this vital group's value for science remains largely unrecognized, its size, contribution, and composition universally unknown and the field generally ignored by disciplined inquiry.

For some time the Society of Research Administrators has realized that many national and institutional issues could not be addressed rationally by the university and their several sponsors until a working definition and a common classification was developed for research support personnel [RSP]. They recognized that the lack of knowledge about this part of the infrastructure was the primary problem leading to a host of secondary difficulties related to the Government-university partnership. Second, they realized that it was creating numerous institutional operating problems directly affecting the daily activities of the principal investigor. Third, it was instigating many personal difficulties related to morale, productivity, and job satisfaction of the research support person.

For example, the secondary problems of capping indirect costs, of decaying support services in the universities, and, of technical personnel shortages within academia and industry stem from inadequate information on research support personnel. Also, valid information related to this group is essential to the development of modern university personnel management systems and to the recruitment, morale, and retention of this essential group of individuals within academia.

Effective and employee-accepted subsystems of performance appraisals, job classification, and equitable employee incentives are dependent upon national norms for particular jobs. Development of these key systems, their specific components and employee satisfaction with their university jobs, requires basic national information and specific national indicators related to this group.

In the past the National Science Foundation has gathered a great deal of information on scientists and engineers, but they have completely neglected this group.

In 1983 the society established a study group to investigate the problems related to the RSP. After 2 years of investigation, the study group has developed:

One, an acceptable definition to universities;

Two, a functional classification system; and

Three, an indepth analysis of divisional research support personnel patterns in universities.

The RSP are now defined as those individuals other than students who render assistance directly or indirectly to principal or coinvestigators. Research support personnel may be assigned directly to a project or they may provide indirect or occasional assistance to the researcher or project director. This heterogeneous group of employees include Ph.D.-level analysts, special mechanics, many types of clerical individuals, and accounting personnel as well as all levels of academic administrators.

The study produced some indicators of the composition of the RSB which I would like to present. To give us a common frame of reference, I call your attention to the SRA "Taxonomy of Research Support Personnel" within the research establishment.

Table II

Analysis of Research in Selected University Departments (1939-40)

Departments of Physics

1 Institution number[a]	2 Number of professional personnel	3 Number of technicians, secretaries, etc.	4 Salaries of professional personnel (thousands)	5 Total department budget (thousands)	6 Direct operating expenses of research[b] (thousands)	7 Ratio column 6 to column 4	8 Percent of research funds from non-university sources	9 Number of graduate students[c]	10 Degrees awarded[c] M. A.	 Ph. D.
1	35	16	$106	$169	$20	0.19	29	57.5	5.2	7.6
2	26	4	41	54	7.5	.18	93	----------	----------	----------
3	51	9	90	115	18	.20	47	37	3	6
4[d]	52	10	92	----------	34.5	.38	20	65	12	5
5	37	7	104	171	[e]39	.38	7	100	10	6
6	56	----------	148	245	27	.18	33	55	3	10
7	18.5	----------	23	30	4	.17	100	14	3	2
8	39.5	10	85	141	41	.48	95	53	8	8
9	31	7	37	62	9	.24	0	50	7	2
11	33	10	54	80	----------	----------	5	35	3	6
12	18	3	27	35	2	.08	100	7	2	2
13	47	13	79	123	30	.38	0	72	4	8

[a] As follows:
1. Large private university.
2. Large State university.
3. Large private university associated with large State agricultural school.
4. Large State university.
5. Large private university.
6. Large private engineering school.
7. Medium size liberal arts university.
8. Medium size private engineering school.
9. Large State university.
10. Medium size private university.
11. Large State university.
12. Medium size State university.
13. Large State university.

[b] Includes expenditures for equipment, apparatus, technical and research assistance, publishing costs associated with research, field trips, expeditions, etc.

[c] Average for the 3 years ending 1939–40.

[d] Includes astronomy and physiological optics.

[e] After deducting $10,000 spent on cyclotron.

For many years the model for research within universities has been primarily researchers and students with a sponsor. This model changes things. The largest group of people in the universities now, excluding students, are research support people. That group has not been looked at. That third dimension that you see running down on the model has really not been investigated by institutional policymakers or national policymakers.

There is a large, large number—almost 75 percent—of the people who in some way make their living associated with university research who are tied up in this group, and it has been completely unstudied. The students have been studied; the researchers have been studied; and certainly the sponsors. There is a large group of them.

This model of the research establishment attempts to explain in a graphic fashion the composition and the complex interaction of the principal types of people in a modern research community. It also provides a shocking picture of the size and significance of the research support personnel. Moreover, it helps institutional data-gathering and policymaking if we have first classified individuals according to their primary purpose.

Each of the classes of individuals has well-defined roles that determine the traditional relationship with one another. If we understand the composition of the establishment, we should be able to formulate policy that facilitates the achievement of research goals.

Note that the support types are in the middle between the researcher and the sponsor. This places them in a brokerage position, making them valuable to both sponsor and the researcher.

You will notice that there are 12 functional classes in the SRA taxonomy for research support people. They range from grants and contracts officers down to medical support personnel.

If you will turn to the next page, you will see a model that is used to classify these individuals. Universities use a variety of organizational structures and support positions to administer research funds. These positions are shown in table IV-1.

Table IV-1
The Typical Divisional Patterns Used by Universities
to Organize Their Research Support Activities
in Grants and Contracts Offices

Directors of Grants and Contract Offices			
Pre-award Division	Post-award Division	Pre-award and Post-award Integration	
Director of Research & Development Director of Community Support Director of Preparation/Review General Mgr. of Devmt. Dean/Director Office of Research	Director of Res. Admin. Director of Grants & Contracts Admin. Director of Projects Devmt. & Admin.	Director of Sponsored Programs Director of Res. Serv. Director of Research Director of Prog. Devmt. & Admin. Director Award Mgmt. & Resources Info. Dir. Fed. Res. Funding Serv. Office Res. & Prog. Admin. Interns (Administrative)	DIRECTORS & DEANS
Assoc. General Mgr. Deputy Dir. Res. Development	Assoc. Dir. Contracts & Grants Deputy Dir. of Prog. Development	Assoc. Dir. Sponsored Programs Deputy Dir. of Sponsored Prog.	ASSOCIATE & DEPUTY DIRECTORS
Assist. Dir. for Research Services Assist. Dir. of Program Devmt. Assist. Dean for Res/Res Prom Svc.	Assist. Dir. of Research Admin. Assist. Mgr. Sponsored Progs. Acctg. Office	Assist. Dir. Office of Prog. & Devmt. Admin. Assist. Dir. Sponsored Programs Admin. Assist. Dir. Sponsored Projects/Bus. Affairs	ASSISTANT DIRECTORS
Coord. Sponsored Programs	Sr. Grants & Contracts Administrator Coord. Grants & Con. Admin. Grants & Contracts Office	Sponsored Projects Administrator Sponsored Programs Administrator Administrative Assistants	ADMINISTRATIVE COORDINATORS ADMINISTRATIVE ASSISTANTS

Some universities use a preaward division, some use a postaward division, and some use an integrated approach, but some place within the university there is someone with the title "Director of Research Sponsored Programs." There are assistants, there are coordinators, and there is a whole list of other types of clerical support.

The next page, table IV-3, you see the composition of the people who are directors of contract offices. You get some idea from a sampling of about 20 institutions of how many males and females you have and a salary range. You can see where some of the costs associated with research go, if you are talking about people who are in support positions.

TABLE IV-3
Gender and Salary of
Grant and Contract Officers

Position Title	Male	Female	Salary Range	Average Salary
Director of Research Development	1	–		
Director of Community Support	–	1	22000 - 22000	22000
Director of Sponsored Programs	6	–	28930 - 45240	35995
Director of Grant & Contract Admin.	2	1	25548 - 44016	36471
Director of Research Devm't & Admin.	1	–	59100 - 59100	59100
Director of Research Administration	3	1	30795 - 40500	34098
Director of Projects				
Director of Prog. Devmt. & Admin.	1	–	45500 - 45500	45500
Director of Preparation/Review Div.	1	–	29224 - 29224	29224
Director of Univ. Res. Foundation	1	–	45152 - 45152	45152
Contract/Grant Specialist	4	4	17950 - 27750	22415
Project Representative	4	2	16200 - 37100	25700
Grants Manager	2	4	17992 - 20000	22918
Administrative Officer	3	–	33521 - 41712	37616
Associate Director	4	1	27250 - 66040	48649
Deputy Director	3	–	38600 - 52200	45386
Assistant Director	6	2	22000 - 45403	32665
Administrative Assistant		1	18000	18000
Total	42	16		

Dave Canham, another study group member, has designed a pattern for classifying business and fiscal officers, still another functional group within this research support group that we have.

Table VI-1. A Pattern for Classifying Business/Fiscal Officer Positions

Vice President Financial Affairs

DIVISION RANK	I CONTROLLING	II ACCOUNTING	III BUSINESS AFFAIRS	IV FISCAL MANAGEMENT	V BUDGETING	VI ADMINISTRATIVE SERVICES
Senior Level Management	Controller	Accounting Manager	Business Manager	Director Fiscal Services	Director Budgeting	Director Administrative Service
Junior Level Management	Assistant Controller	Director of Accounting	Assistant Business Manager	Fiscal Manager Assistant Director Fiscal Services	Manager Budgets	
Senior Operational Positions	Audit Supervisor	Chief or Senior Accountant		Fiscal Coordinator	Budget Analyst I,II,III	
Junior Operational Positions	Auditor	Accountant I,II,III,IV,V		Fiscal I,II,III	Accounting	
Para-Professionals		Accounting Associate				
Apprentices		Accounting Technician				

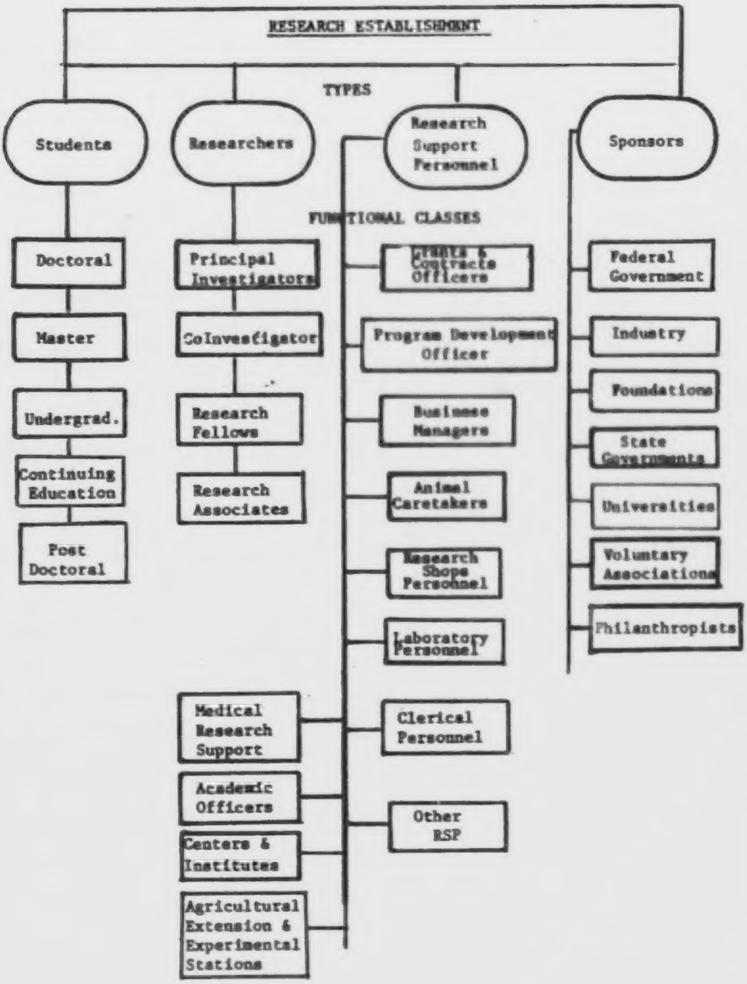
There have been 10 other study members who have made intensive studies of their functional classes and have provided a current picture of the composition of their category of research support.

Taken together, these 12 studies provide the best indicators of what positions are included in the university research infrastructure.

The study group estimates that currently 75 percent of the total research personnel are employed in support positions. If you will turn two pages over, you will see a copy of the SRA summary results. Here you see an example of where institutions have 1,700 faculties but 7,300 support personnel, giving them a percentage of faculty at 19 percent with 81 percent of support people. If you will look at the amount of money that they are getting in the way of Federal research funds, you see that they are getting over $200 million in Federal support to support research.

Some idea of the size of the group can be found if we look at table II, called an "Analysis of Research at Selected University Departments (1939–40)." At that time Vannevar Bush reported that there was approximately 82 percent faculty in relation to 18 percent support people in 1940, in the beginning where university research began to really take off and grow very, very rapidly.

Figure 1.
IP2.0 The SRA Taxonomy For the Research Support Personnel within the Research Establishment



Many of us still hold that outmoded concept in mind, that we think of an investigator and maybe a part-time person supporting. That type of research still exists in universities, but it is not the type of university research that we really have. We have a few investigators and a large support group.

One of the problems that comes up is the indirect cost. Reducing rapidly increasing indirect costs is of considerable concern to the Congress, to the scientific community, and to users of basic research and technological innovation. The disproportionate continuous, rising, indirect cost for university research is one of the most serious and frequently discussed problems confronting the academe today. That rise in indirect costs can be partially explained by a related rise in the percent of research support people in universities.

We constantly talk about the rising indirect cost rates. We must constantly think also about the infrastructure that it takes to support that, and the infrastructure is pretty much captured in our indirect cost return.

If one reviews the arguments for indirect costs, it is obvious that neither university administrators nor Government officials know enough about the support cost, nor do they have the foundation information on the research support personnel, to justify those costs to the faculty or to the taxpayer.

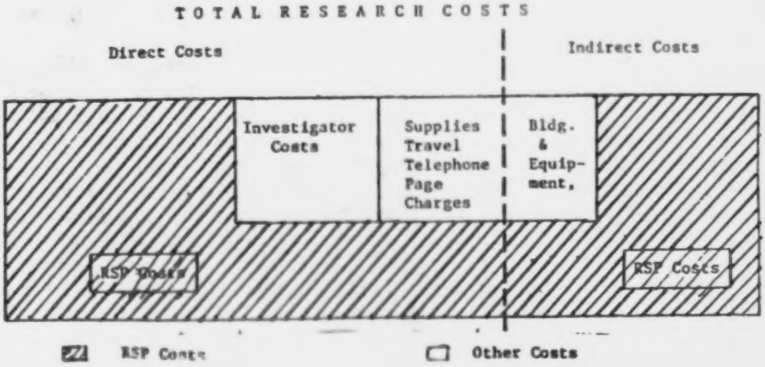
Earlier we saw that research support people are estimated to be at least 75 percent of the total research personnel. They can be directly or indirectly identified with some kind of research function.

At this time we should look at the total cost of university research. That means looking both at the direct cost and the indirect cost, and then look at the contribution that research support people make to these costs.

Since most universities cannot presently determine exactly who and for how much time each research support personnel is assigned to an organized research unit, it is impossible to say precisely what the mix of costs are within university organized research budgets, but one writer guessed that the principal investigator costs are less than 20 percent of total direct cost for research and that research support people account for more than 50 percent of the total research cost. Moreover, the trend is for more research support costs; thus, higher indirect cost rates.

Figure 4 shows three university research administrators' opinions about what the relationship and the distribution might be among major cost factors in university research. Exact knowledge of this ratio should be determined.

FIGURE 4. A GRAPHIC REPRESENTATION OF ESTIMATED RSP COSTS IN RELATION TO TOTAL UNIVERSITY RESEARCH COSTS.



During the past 5 years I have given the questionnaire on size and significance of research support personnel to several hundred faculty and science policymakers to determine their image of the size and significance of the research support personnel. Most of those interviewed have dangerously low estimates of the size of this group and hold an outmoded picture of how research is organized and conducted on today's campus.

Moreover, they conceive of university research in an antiquated and parochial fashion. Most look upon university research as being confined to basic research. This narrow, personal image is reinforced by the Bowman model for American research which was adopted informally by the Federal Government in the forties when Vannevar Bush sent to President Harry S. Truman his recommendations for the advancement of national research.

Isaiah Bowman, in his recommendations, maintained that scientific research could be divided into three broad categories: one, pure research; two, background research; three, applied research and development.

Briefly stated, Bowman suggested that pure research should be performed by universities and applied research and development should be conducted by industry, with some being done by Government labs. He provided an elaborate rationale to explain the proper roles and relationships of public and private research organizations and to guide the Government's aid to them.

Today, the National Science Foundation uses categories 1 and 3 of the Bowman model to gather scientific information from universities. Most agency directors and university administrators have adopted the conventional rationale set forth by Bowman in "Science—the Endless Frontier."

A large part of existing Government and university policy starts with the Bowman model. Today policymakers now use current NSF data and the Bowman model to formulate new policy.

It is my opinion that the Bowman model is inappropriate for understanding today's research activities, as it discourages scientific interaction and it does not allow a quantification of the products of research. I suggest that the 1984 model to classify university research activities, which you will see on the next page, is more representative of what the universities presently do and is a more powerful and precise model for information gathering on university research. More importantly, this model encourages the development of industrial as well as Government sponsorship of university research. The 1984 model is more realistic as it shows the vast scope of innovative problem-solving activities that society currently demands of the university, in addition to the university's conventional training mission.

[illegible]

A MODEL FOR CLASSIFYING UNIVERSITY RESEARCH ACTIVITIES

CLASSES OF ACTIVITIES	BASIC RESEARCH	APPLIED RESEARCH	DEVELOPMENT	PRODUCTION RESEARCH	TECHNOLOGICAL INNOVATION
A	DISCIPLINARY IMPERATIVES	SOCIAL UTILITY	ORGANIZATION PRIORITIES	MARKET MANDATES	SOCIAL/DISCIPLINARY NEEDS
PROCESS B	EXPLORING NATURAL/HUMAN PHENOMENA	RENDERING INTO PRACTICE	STEPPING UP-A MODEL SOLUTION	PRODUCTIVITY IMPROVEMENT	INTERDISCIPLINARY/ INTERSECTOR IDEAS
OUTPUTS C	KNOWLEDGE ARTICLE ALGORITHM	INVENTIONS PATENTS/ TRADE SECRETS/ COPYRIGHT	PROTOTYPES	PRODUCTS GOODS/SERVICES	ADOPTION OF AN INNOVATION

Policymakers must understand that universities perform the vital task of creating new knowledge, of inventing new devices, of developing prototypes, of improving production of goods and services, and of transferring technology.

Not only has the scope of the work of the university expanded, but the volume of the work has increased many hundredfold. In 1939 to 1940 the total university research expenditure was $30 million. In 1985 the expenditure is well over $10 billion, a 300-fold increase.

Universities have been transformed in the past 40 years. University research is big business. It provides the fuel, innovation that propels our technological society. Slow the production of these innovations and American technology is slowed. There is a widespread perception that scientists and engineers are usually the people who conceive our inventions. This is true, but we have scotomas in our national and institutional policies that have long excluded the research support person, a group essential for universities to conduct modern science and to produce an expanding variety of innovations. To draft policy that will facilitate research, we must not only have new data; we must have realistic personal perceptions of the subject and valid models to follow.

I am pleased that the Science and Technology Committee has structured a broad-ranging study of Government science policy. A comprehensive reassessment of the relationship among the organizations and the research establishment is much needed. Your hearings are most timely, as I believe that our research universities are caught in a great wave of technological change that requires both national and institutional policymakers to assess both our policy and our national models, in light of four decades of dramatic university transformation that promises to become increasingly more rapid in the remaining years of this century.

Hopefully, the results of your study will stimulate and provide a guide for self-studies by universities and professional associations.

I thank you.

[The prepared statement of Dr. Hensley follows:]

The Significance of Research Support Personnel (RSP) to University Research and Their Impact on Research Policy

I am Oliver Hensley, Associate Vice President for Research at Texas Tech University and Chairman of the Society of Research Administrators Study Group on RSP. I want to thank the Task Force for inviting me to testify about the significance of Research Support Personnel (RSP) to university research and about their impact on national and university research policy. The topic is most important to the continuing excellence of university research and to the welfare of the nation.

The Task Force has asked for a broad review of the entire question of the composition of the university research infrastructure and the role of the government in providing and maintaining it.

I will begin by sharing with you some personal impressions about research support personnel and then point out some of the highlights of recent developments from the comprehensive SRA Study of the RSP. (1) The significance of the RSP to research is not understood by policy makers; consequently they have been ignored. (2) The exact size of the total RSP population is not presently known, but there are estimates that they number more than a half-million. (3) The present national cost of maintaining university research support personnel is enormous and their costs are increasing at an astounding rate. (4) Quality support services can be maintained with a strong Congressional commitment to support this part of the infrastructure. (5) The direct and indirect cost reimbursement mechanism associated with project funding is an adequate and a fair way of maintaining the infrastructure if policy makers will accept the fact that the FULL costs for research must be recovered for every project and if policy makers will update their personal perceptions and formal models to keep pace with the changing times. And, (6) a continuing, comprehensive study can be made of the RSP and other segments of the infrastructure if Congress, the NSF and the professional associations such as SRA will arrange for and support the periodical exchange of timely information. Your hearings are an excellent start in that direction. The SRA will respond by inviting one of your members to speak about the Task Force agenda at our national conference in St. Louis on October 1, 1985.

In a moment I will provide some crude indicators of the size and composition of the RSP which in my opinion currently constitutes the greatest single segment of university research costs. As an expenditure item in the annual budget it is far greater than buildings, equipment, materials and supplies and, yes, even larger than the costs for the support of principal investigators. This is not a commonly held opinion in the research establishment as the data to support this opinion is scanty and the thesis only recently formed. Nevertheless, there is mounting evidence that support personnel are now the largest group on campus if students are excluded.

The Significance of RSP Is Not Understood

The SRA Study Group on RSP found that Federal agencies, university associations and the professional societies have not valued the RSP enough to distinguish them from other groups and then to study them.

They also found that there was wide acknowledgement that RSP, the largest group of personnel in research universities, excluding students, are essential to the continued advancement of science, to the achievement of the specific missions of post-secondary institutions, and to American technological leadership. Yet, this vital group's value for science remains largely unrecognized; its size, contributions, and composition universally unknown; and the field generally ignored by disciplined inquiry. A literature search brought out the fact that the RSP are incidentally mentioned in studies by the National Research Council, the National Academies and the federal science agencies "as large groups of people vital to the success of the research enterprise" and then these agencies effectively ignore the problems of the RSP by immediately moving on to what they consider to be more critical issues. In a survey of major research universities, the Study Group had a very poor response from officers responsible for personnel data gathering. They disclaimed any responsibility for distinguishing this class of employee as the RSP are not perceived to have a high priority for study within their institutions.

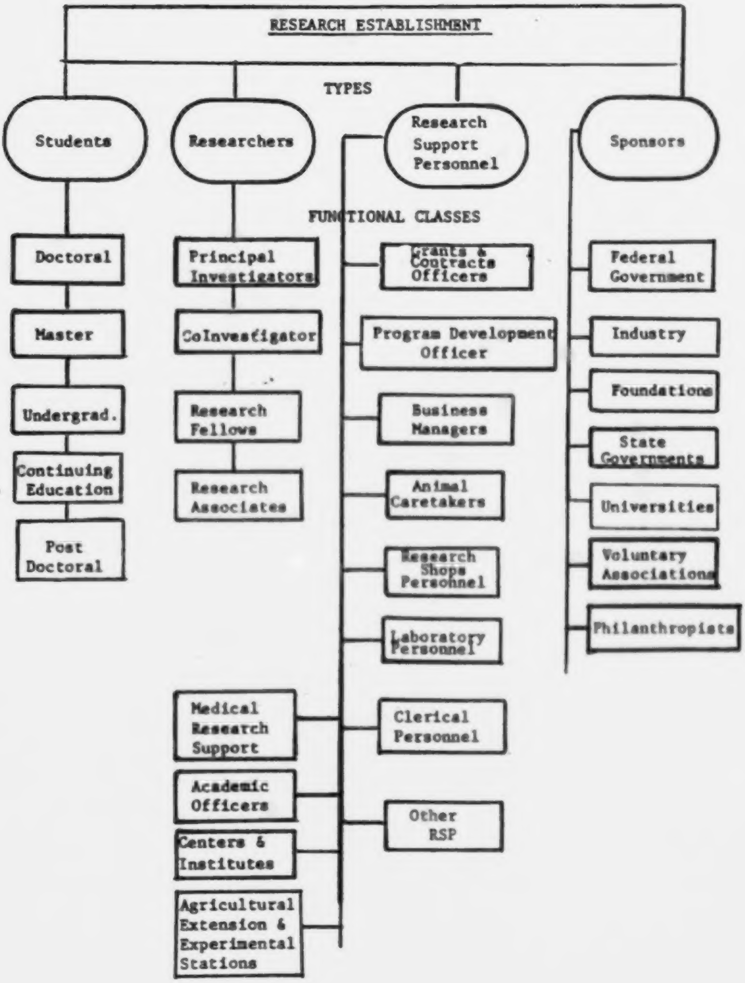
For some time, the Society of Research Administrators has realized that many vital national and institutional issues could not be addressed by the university and their several sponsors until a working definition and a common classification system was developed for research support personnel. They recognized that the lack of knowledge about the RSP was the PRIMARY PROBLEM leading to a host of secondary difficulties related to the government/university partnership; creating numerous institutional-operating-problems directly affecting the daily activities of the principal investigator; and instigating many personal difficulties related to morale, productivity, and job satisfaction of the research support person. For example, the secondary problems of capping indirect costs, of decaying support services, and of technical personnel shortages within academe and industry stem from inadequate information on the RSP. Also, valid information related to this group is essential to the development of modern university personnel management systems and to the recruitment, morale, and retention of these essential individuals within the academy. Effective and employee-accepted subsystems for performance appraisals, job classification and equitable employee incentives are dependent upon national norms for particular jobs. Development of these key systems, their specific components, and employee satisfaction with their university jobs requires basic, national information and specific indicators related to this group.

In 1983 the Society established a Study Group to investigate the problems related to the RSP. After two years of investigation the Study Group has developed an acceptable definition, a functional classification system and in-depth analysis of divisional RSP patterns in universities. Research Support Personnel (RSP) are now defined as those individuals (other than students) who render assistance directly or indirectly to principal or co-investigators. Research Support Personnel may be assigned directly to a project or they may provide indirect or occasional assistance to the researcher or project director. This heterogeneous group of employees includes Ph.D.-level analysts, special mechanics, and general clerical and accounting personnel, as well as academic administrators.

Some Indicators of the Composition of the RSP

To give us a common frame of reference I call your attention to Figure 1, Taxonomy for Research Support Personnel Within The University

Figure 1.
IF2.0 The SRA Taxonomy For the Research Support Personnel within the Research Establishment



Research Establishment. This model attempts to explain in a graphic fashion the composition and complex interactions of the principal types of people in the modern research community. It helps in our data gathering and policy making if we can classify individuals first by their primary purposes as:

(1) Students
(2) Researchers
(3) Research Support Personnel
(4) Sponsors

Each of these classes of individuals have well defined roles that determine the traditional relationships with one another. If we understand the composition of the establishment, we should be able to formulate policy that facilitates the achievement of research goals. Note that the support types are in the middle between the researcher and sponsor. This places them in a brokerage position making them valuable to both the sponsor and the researcher.

You will notice that there are twelve functional classes in the SRA Taxonomy of RSP.

- Grant and Contract Office Directors
- Business Managers
- Research Shop Personnel
- Clerical Personnel
- Research Center Personnel
- Medical Personnel
- Program Development Officers
- Animal Care Personnel
- Laboratory Personnel
- Academic Officers
- Agricultural Extension Personnel
- Other RSP

Within each of the functional classes you will notice Divisional Patterns such as those Dr. Charles Gale has prepared for the Directors

Table IV-1
The Typical Divisional Patterns Used by Universities
to Organize Their Research Support Activities
in Grants and Contracts Offices

Directors of Grants
and Contract Offices

Pre-award Division	Post-award Division	Pre-award and Post-award Integration	
Director of Research & Development Director of Community Support Director of Preparation/Review General Mgr. of Devmt. Dean/Director Office of Research	Director of Res. Admin. Director of Grants & Contracts Admin. Director of Projects Devmt. & Admin.	Director of Sponsored Programs Director of Res. Serv. Director of Research Director of Prog. Devmt. & Admin. Director Award Mgmt. & Resources Info. Dir. Fed. Res. Funding Serv. Office Res. & Prog. Admin. Interns (Administrative)	DIRECTORS & DEANS
Assoc. General Mgr. Deputy Dir. Res. Development	Assoc. Dir. Contracts & Grants Deputy Dir. of Prog. Development	Assoc. Dir. Sponsored Programs Deputy Dir. of Sponsored Prog.	ASSOCIATE & DEPUTY DIRECTORS
Assist. Dir. for Research Services Assist. Dir. of Programs Devmt. Assist. Dean for Res/Res Prom Svc.	Assist. Dir. of Research Admin. Assist. Mgr. Sponsored Progs. Acctg. Office	Assist. Dir. Office of Prog. & Devmt. Admin. Assist. Dir. Sponsored Programs Admin. Assist. Dir. Sponsored Projects/Bus. Affairs	ASSISTANT DIRECTORS
Coord. Sponsored Programs	Sr. Grants & Contracts Administrator Coord. Grants & Con. Admin. Grants & Contracts Office	Sponsored Projects Administrator Sponsored Programs Administrator Administrative Assistants	ADMINISTRATIVE COORDINATORS ADMINISTRATIVE ASSISTANTS

TABLE IV-3
Gender and Salary of
Grant and Contract Officers

Position Title	Male	Female	Salary Range	Average Salary
Director of Research Development	1	-		
Director of Community Support	-	1	22000 - 22000	22000
Director of Sponsored Programs	6	-	28930 - 45240	35995
Director of Grant & Contract Admin.	2	1	25548 - 44016	36471
Director of Research Deve't & Admin.	1	-	59100 - 59100	59100
Director of Research Administration	3	1	30795 - 40500	34098
Director of Projects				
Director of Prog. Devmt. & Admin.	1	-	45500 - 45500	45500
Director of Preparation/Review Div.	1	-	29224 - 29224	29224
Director of Univ. Res. Foundation	1	-	45152 - 45152	45152
Contract/Grant Specialist	4	4	17950 - 27750	22415
Project Representative	4	2	16200 - 37100	25700
Grants Manager	2	4	17992 - 20000	22918
Administrative Officer	3	-	33521 - 41712	37616
Associate Director	4	1	27250 - 66040	48649
Deputy Director	3	-	38600 - 52200	45386
Assistant Director	6	2	22000 - 45403	32665
Administrative Assistant		1	18000	18000
Total	42	18		

of Grant and Contract Offices, Table IV-1. In Table IV-3 a further analysis is made of the composition of the class by providing statistics on gender and salary.

Dave Canham, another Study Group member, has designed A Pattern for Classifying Business/Fiscal Officer Positions (Table VI-1) and has completed a thorough analysis of gender and salary ranges for 577 subjects in fiscal officer positions. Ten other Study Group members have made intensive studies of their functional class and have provided a current picture of the composition of their class of RSP. Taken together these studies provide the best indicators of what RSP are included in the university research infrastructure.

The Size and Growth of the RSP. Currently no one in the United States knows the size of RSP in American universities. This lack of knowledge leads to a number of misconceptions of the composition of the research establishment and the significance of the RSP to higher education and research advancement. Although there are no current official records, one can obtain an idea of the growth of the RSP in the university from occasional statistics related to different groups within the university. Statistics such as those published by Bush (13a) show that selected university departments held a ratio of 82% professional, to 18% support personnel in 1939-1940.

Table VI-1. A Pattern for Classifying Business/Fiscal Officer Positions

Vice President Financial Affairs

DIVISION RANK	I CONTROLLING	II ACCOUNTING	III BUSINESS AFFAIRS	IV FISCAL MANAGEMENT	V BUDGETING	VI ADMINISTRATIVE SERVICES
Senior Level Management	Controller	Accounting Manager	Business Manager	Director Fiscal Services	Director Budgeting	Director Administrative Service
Junior Level Management	Assistant Controller	Director of Accounting	Assistant Business Manager	Fiscal Manager Assistant Director Fiscal Services	Manager Budgets	
Senior Operational Positions	Audit Supervisor	Chief or Senior Accountant		Fiscal Coordinator	Budget Analyst I,II,III	
Junior Operational Positions	Auditor	Accountant I,II,III,IV,V		Fiscal I,II,III	Accounting	
Para-Professionals		Accounting Associate				
Apprentices		Accounting Technician				

Table II

Analysis of Research in Selected University Departments (1939-40)

Departments of Physics

1 Institution number a	2 Number of professional personnel	3 Number of assistants, technicians, etc.	4 Salaries of professional personnel (thousands)	5 Total department budget (thousands)	6 Direct operating expenses of research b (thousands)	7 Ratio column 6 to column 4	8 Percent of research funds from non-university sources	9 Number of graduate students c	10 Degrees awarded c M. A.	 Ph. D.
1	35	18	$106	$169	$20	0.19	20	87.5	5.2	7.6
2	28	4	41	54	7.5	.18	93			
3	51	9	90	115	18	.20	47	37	3	6
4 d	82	10	92		24.5	.26	20	65	12	5
5	37	7	104	171	e 35	.33	7	100	10	6
6	66		148	245	27	.18	33	56	3	10
7	18.5		23	30	4	.17	100	14	3	2
8	20.5	13	85	141	41	.48	95	53	8	8
9	31	7	37	62	9	.24	0	50	7	2
11	22	10	54	80			5	35	3	6
12	18	3	27	35	2	.08	100	7	2	2
13	47	13	79	123	30	.38	0	72	4	8

a As follows:
1. Large private university.
2. Large State university.
3. Large private university associated with large State agricultural school.
4. Large State university.
5. Large private university.
6. Large private engineering school.
7. Medium size liberal arts university.
8. Medium size private engineering school.
9. Large State university.
10. Medium size private university.
11. Large State university.
12. Medium size State university.
13. Large State university.

b Includes expenditures for equipment, apparatus, technical and research assistants, publishing costs associated with research, field trips, expeditions, etc.

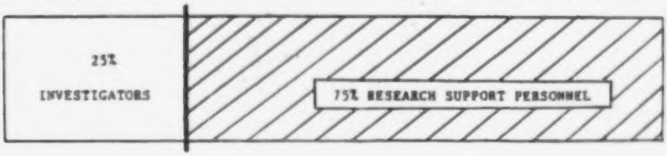
c Average for the 3 years ending 1939-40.

d Includes astronomy and physiological optics.

e After deducting $10,000 spent on cyclotron.

The SRA Research Committee guessed in 1983 that there were probably 3 or more RSP for every investigator in their institutions (76). Although limited to 20 institutions, the returns of the 1983 SRA Survey support that estimate showing a ratio of 25% of Faculty to 75% Support Personnel. These figures exclude graduate and undergraduate students. From these information sources, Hensley and Grace (CC) made the following rough estimate for distribution of research support personnel in research universities in 1984 and they estimated the total RSP in American universities to be well over 500,000 members. Unfortunately, there has been no exact determination of their number, but the Summary results from the SRA Survey of RSP 1983 show the wide range of percentages of RSP in individual universities. As one might expect the research universities had a much higher percentage of RSP than did the institutions with an undergraduate instructional orientation. One research institution reported a high ratio of 89% RSP to 11% faculty while another institution with a small amount of research reported only a 53% RSP to 47.1% faculty. Although the correlation is not perfect, crude preliminary data indicates that higher education institutions with large expenditures for research have a high percentage of support personnel.

FIGURE 1. ESTIMATED DISTRIBUTION OF RESEARCH PERSONNEL WITHIN THE UNIVERSITY 1983.



A comparison of 1984 statistics with the 1939-40 statistics show a reversal in the mix of professional and support personnel. Today, there seems to be more RSP than researchers.

If we are to understand the phenomenal growth and the significance of this overlooked group, we should investigate first the rapidly expanding role that university research plays in American society as the size of the total RSP is dependent upon that variable. Next, we should think about the increasing functions that the RSP assume in the development of research as their value is related to their performance of support activities. All of us make decisions based on our personal images of real world subjects and on professionally accepted formal models of what the collective mind tells us is the larger and more generally accepted representation of reality. Our policy making is derived from those images. Therefore, any review of institutional and national policy must begin with an assessment of the personal perceptions of policy makers about the size and significance of the RSP to modern science and then consider those images in the mosaic of existing policy that guides individual actions and institutional data gathering.

The Cost of Maintaining Research Support Personnel. If RSP are to be maintained the Federal government must supply the full cost of federally sponsored research. Similarly, industry, the states, and foundations should supply their full share of indirect costs. If each sponsor pays their freight for the RSP, there will be few problems with maintaining the university research infrastructure . Unfortunately, the relationship between the value of RSP and the rising indirect cost rates is not understood by many members of the research establishment.

SRA 1983 SUMMARY RESULT

	FACULTY	PERCENT OF TOTAL	SUPPORT PERSONNEL	PERCENT OF TOTAL	TOTAL PERSONNEL	FEDERAL RESEARCH AWARDS
1.	1,700	18.8%	7,300	81.2%	9,000	239,869,000
2.	4,021	18.9%	17,200	81.1%	21,221	71,204,000
3.	1,917	29.5%	4,583	70.5%	6,500	41,850,060
4.	2,780	19.3%	11,627	80.7%	14,407	37,034,000
5.	1,870	23.8%	5,985	76.2%	7,855	26,367,000
6.	109	11.0%	880	89.0%	989	23,415,000
7.	1,505	19.0%	6,382	81.0%	7,887	13,933,000
8.	1,271	36.6%	2,202	63.4%	3,473	13,162,000
9.	710	23.7%	2,285	76.3%	2,995	10,484,000
10.	858	25.0%	2,569	75.0%	3,427	10,263,000
11.	550	20.0%	2,200	80.0%	2,750	9,776,000
12.	845	26.4%	2,355	73.6%	3,200	8,450,000
13.	888	21.8%	3,180	78.2%	4,068	7,979,000
14.	829	37.7%	1,371	62.3%	2,200	7,177,000
15.	939	31.0%	2,094	69.0%	3,033	6,221,000
16.	830	33.2%	1,670	66.8%	2,500	5,477,000
17.	1,770	38.6%	2,815	61.4%	4,585	2,923,000
18.	330	33.3%	600	66.7%	930	2,628,000
19.	458	24.5%	1,414	75.5%	1,872	1,523,000
20.	400	47.1%	450	52.9%	850	1,039,000
TOTALS	24,580	23.7%	79,162	76.3%	103,742	

A large number of secondary national and institutional issues (deteriorating laboratory conditions, personnel shortages, performance appraisals, merit salary increases, allocation of shrinking resources, affirmative action employment, and rising indirect costs) are constantly being raised in every quarter of the research community and each could use its own full related literature search to convince the reader of the importance of the RSP to each issue. We will review in this testimony only one issue--the relationship of the increasing RSP numbers and their productivity to the escalating indirect costs.

Reducing rapidly increasing indirect costs is of considerable concern to Congress, to the scientific community, and to users of basic research and technological innovation. The disproportionate, continuous rising indirect costs for university research is one of the most serious and frequently discussed problems confronting the academy today. Gross (33), Warner (83), Wyngaarden (86), and others have complained about a wide range of problems, yet no one has systematically and empirically identified the components of the problem. Lang (47), notes that the determination of what is an "indirect" cost as distinguished from a "direct cost" is to a large extent arbitrary, and depends on political, subjective judgments. Lang (48) has been told by administrators "that if pressed too much on 'indirect costs' university administrators will find it necessary to adapt their accounting systems to claim as a direct cost what is now classified as indirect." All of this leads into extremely complicated tertiary questions of funding, political pressures, and the value of the RSP. Stokes (75) noted in his analyses of the top 100 universities indirect cost policies that there were significant differences between the administrative groups (business officers and research administrators) and research faculty on the general topic of indirect costs. Also, the professional societies (26, 31, 47) have accused the university administrator with ducking and dodging the fundamental issue of indirect costs, and have characterized the assignment of costs as a four-dimensional shell game. Several long-time university administrators felt the conflict between faculty and administrators and universities and sponsors should be reduced with a rational accounting of RSP costs, and called to NCURA and SRA's attention that the lack of standards for classification prevents cooperation between the fiscal side of university management and the science side.

When testifying to the Committee on Science and Technology of the House of Representatives on 24 March 1980, David Saxton, President of the University of California, recognized varying points of view and acknowledged that there was vast disagreement among elements within the research establishment as to who bears the expense of rising indirect costs. He cautioned,

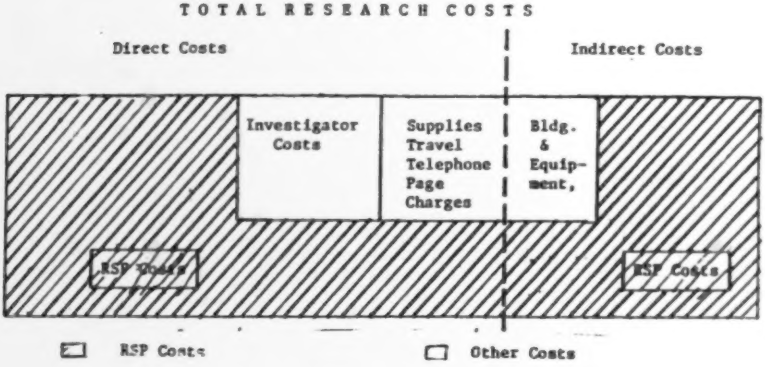
> In trying to come to grips with this issue (of Circular A-21), we are not dealing with a couple of monoliths; the Federal Government does not present an absolute unified view of the issues, and on the other side, neither do the universities. Our faculty, for example, is as convinced as anyone in the Government that indirect costs are too high. They believe that indirect costs come at the expense of their own grants.

It is obvious that neither university administrators nor government officials know enough about the support costs nor do they have the foundation information on RSP to justify these costs to faculty or taxpayers.

Earlier we saw that RSP are estimated to be at least 75% of the total research personnel who can be directly or indirectly identified with some research function. At this time, we should look at the total costs of university research, direct costs and indirect costs, and the estimated contribution of the RSP to those costs.

Since most universities cannot presently determine exactly who and for how much time each RSP is assigned to an organized research unit, it is impossible to say precisely what the mix of costs are within the university organized research budget, but one writer guessed that principal investigator costs are less than 20% of total direct costs for research and that the RSP account for more than 50% of total research costs and that RSP costs are rapidly growing. Figure 4 shows three university administrator's opinions about what the relationship and distribution might be among the major cost factors in university research (CF). Exact knowledge of this ratio should be determined.

FIGURE 4. A GRAPHIC REPRESENTATION OF ESTIMATED RSP COSTS IN RELATION TO TOTAL UNIVERSITY RESEARCH COSTS.



Anderson (3), Hensley (40), and Jung (44) have postulated that the alarming increases in agency indirect cost rates are only a gross indicator of the declining quality of work and is a contributing factor to rising support costs. They analyzed the work-social interaction of RSP in six institutions and found that certain employees spend better than 80% of the "working hours" on work related activities; however, other employees spend less than 30% of their working-time on work related activities. These findings should be more frightening than the 150% increase in indirect costs as these costs would not show up in indirect cost studies (87).

During the past five years I have given the Questionnaire on the Size and Significahce of RSP to several hundred faculty and science policy makers to determine their image of the size and significance of the RSP. Most of those interviewed have dangerously low estimates of the size of the RSP and hold an outmoded picture of how research is organized and conducted on today's capus. Moreover, they conceive of university research in an antiquated and parochial fashion. Most look upon university research as being confined to basic research. This narrow personal image is reinforced by the Bowman Model for American research which was adopted informally by the Federal government in the forties when Vannevar Bush sent to President Harry S. Truman his recommendations for the advancement of national research. Isaiah Bowman in those recommendations maintained that scientific research could be divided into three broad categories: (1) pure research; (2) background research; and (3) applied research and development. Briefly stated, Bowman suggested that pure research should be performed by universities and applied research and development should be conducted by industry with

with some being done by government labs. He provided an elaborate rationale to explain the proper roles and relationships of public and private research organizations and to guide the governments aid to them. Today, NSF uses categories (1) and (3) to gather scientific information from universities and most agency directors and university administrators have adopted the conventional rationale set forth in Science--The Endless Frontier. A large part of government and university policy starts with the Bowman Model and then uses NSF data as their base to formulate policy.

It is my opinion that the Bowman Model is inappropriate for understanding today's research activities, as it discourages scientific interaction, and it does not allow a quantification of the products of research. I suggest that the 1984 Model for Classifying University Research Activities is more representative of what universities presently do and is a more powerful and precise model for information gathering on university research. More importantly this model encourages the development of industrial as well as government sponsorship of university research. The 1984 Model is more realistic as it shows the vast scope of innovative problem solving activities that society currently demands of the university, in addition to its conventional training mission. Policy makers must understand that universities perform the vital tasks of (1) creating new knowledge, (2) inventing new devices, (3) developing prototypes, (4) improving production of goods and sevices, and (5) transferring technology. Not only has the scope of the work expanded, but the volume of work has increased many hundred-fold.

[illegible]

A MODEL FOR CLASSIFYING UNIVERSITY RESEARCH ACTIVITIES

CLASSES OF ACTIVITIES		BASIC RESEARCH	APPLIED RESEARCH	DEVELOPMENT	PRODUCTION RESEARCH	TECHNOLOGICAL INNOVATION
	A	DISCIPLINARY IMPERATIVES	SOCIAL UTILITY	ORGANIZATION PRIORITIES	MARKET MANDATES	SOCIAL/DISCIPLINAR NEEDS
PROCESS	B	EXPLORING NATURAL/HUMAN PHENOMENA	RENDERING INTO PRACTICE	STEPPING UP-A MODEL SOLUTION	PRODUCTIVITY IMPROVEMENT	INTERDISCIPLINARY/ INTERSECTOR IDEAS
OUTPUTS	C	KNOWLEDGE ARTICLE ALGORITHM	INVENTIONS PATENTS/ TRADE SECRETS/ COPYRIGHT	PROTOTYPES	PRODUCTS GOODS/SERVICES	ADOPTION OF AN INNOVATION

Universities are big business. They provide the fuel and innovation that propels our technological society. Slow the production of innovation and technology is slowed. There is a widespread perception that scientists and engineers are usually the people who conceive our innovations--this is true; but nationally we have scotomas that have long excluded the RSP--a group essential for universities to conduct modern science and produce an expanding variety of innovations. To draft policy that will facilitate research, we must not only have new data, we must also have realistic personal perceptions of the subject and valid models.

I am pleased that the Science and Technology Committee has structured a broad ranging study of government science policy. A comprehensive reassessment of the relationships among the organizations in the research establishment is much needed. Your hearings are most timely, as I believe that our research universities are caught in a great wave of technological change that requires both national and institutional policy makers to reassess our policies and national models in the light of four decades of dramatic university transformation that promises to become increasingly more rapid in the remaining years of this century. Hopefully, the results of your study will stimulate and provide a guide for self studies by universities and professional associations.

Mr. **Fuqua**. Thank you very much, Dr. Hensley.

I think at this point we will take a short recess while we go vote.

What we will do today, in the interest of time, because I also think many of the questions are interrelated to each other, is that we will hear from all of the other witnesses and then we will have questions at the end of everyone.

Dr. **Hensley**. I will remain.

[Recess taken.]

Mr. **Fuqua**. We will resume the meeting.

We have three other members who have not spoken. If the three other members will take their places at the table, we will resume with Mr. Smith, who is senior vice president of the Council for Financial Aid to Education.

STATEMENT OF HAYDEN W. SMITH, SENIOR VICE PRESIDENT, COUNCIL FOR FINANCIAL AID TO EDUCATION, NEW YORK, NY

Mr. **Smith**. Thank you, Mr. Chairman.

It is a pleasure to appear before this task force. The Council is very appreciative of the opportunity to share some of its information and hopes that it will be useful to the work of this committee. The Council is known throughout the corporate and academic worlds as CFAE. I will use those initials here.

By way of identification, CFAE is a nonprofit service agency created in 1952 by eminent business leaders. Its purpose is to encourage the widest possible support of higher education by private donors, especially the corporate community itself. It is supported exclusively by voluntary contributions from some 400 business corporations, and our program consists of research, publications, and consultations with business executives—all designed to encourage corporate support of higher education. We are best known to the corporate community at large through a public service advertising campaign that uses the well-known slogan, "Give to the College of Your Choice."

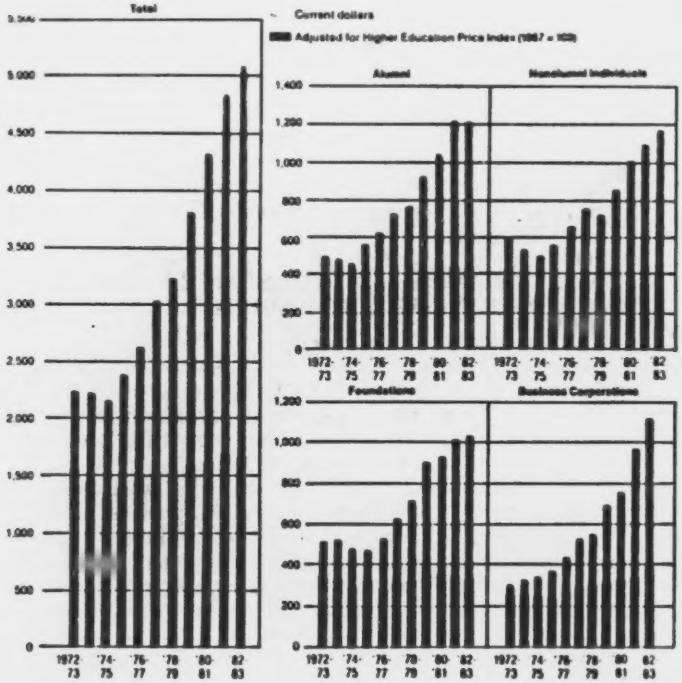
I am appearing here today to provide the task force with some information on the extent to which private donors, including individuals, industrial firms, and foundations, have supported the acquisition and maintenance of the research infrastructure in American universities. I intend also to comment on current and future trends of this type of support and to discuss several elements of Federal fiscal policy that impinge on donors' incentives.

Among the research activities for which CFAE is well known is its annual survey of voluntary support of education. We are the only agency that gathers such data, and we are the leading authority on this type of information. I have previously furnished to the task force copies of our 1982-83 survey report, and I would like to walk you through a couple of the numbers in here, just to highlight the findings.

If you will turn to page 3 in this report, you will find charts which depict our estimates of the total voluntary support received by all colleges and universities. These estimates are prepared from our survey findings and they take into account the relative importance of different kinds of institutions and the differential response rates that come from them.

Chart 1. Estimated Voluntary Support of Colleges and Universities by Major Sources and in Total

(millions of dollars)



The chart on the left shows that voluntary support rose from $2.16 billion in 1975, which was a recession year, to $5.16 billion in 1983. Although we don't have a complete analysis of the data from the 1984 survey at this time, there is enough information off our computer to permit an estimate of $5.6 billion. This implies the private giving to higher education has increased at an average rate of 11.2 percent per year over the last 9 years, which, when corrected for inflation, represents a real growth of about 3.5 percent annually.

If you will turn to page 4, table 1 gives a breakdown of our estimates by source and by purpose. The individual donors, you will note, account for roughly half of all voluntary support, and the dollars are divided about equally between institutional alumni and all other individuals. Business corporations and private foundations account for about one-fifth of the total; the remainder comes from religious denominations and a variety of other sources.

Table 1. Estimated Voluntary Support by Source and Purpose (millions)

	1977-78	1981-82	1982-83	% Change, 1982-83 v. 1981-82	v. 1977-78	v. 1977-78 adj. for HEPI
TOTAL VOLUNTARY SUPPORT	$3,040	$4,860	$5,160	+ 6.2	+ 69.7	+ 10.7
Sources						
Alumni	$ 714	$1,240*	$1,237	− 0.2	+ 73.2	+ 13.0
Nonalumni Individuals	766	1,097	1,190	+ 8.4	+ 55.4	+ 5.0
Foundations	623	1,003	1,018	+ 1.4	+ 63.4	+ 6.8
Business Corporations	508	976**	1,112	+ 13.9	+ 118.9	+ 42.9
Religious Denominations	158	175	206	+ 17.7	+ 30.4	− 14.1
Other	271	369	397	+ 7.6	+ 46.4	− 4.4
Purposes						
Unrestricted	$ 934	$1,348	$1,506	+ 11.7	+ 61.2	+ 5.2
Physical Plant	447	747	791	+ 5.9	+ 77.0	+ 15.3
Research	480	676	750	+ 10.9	+ 56.3	+ 2.1
Student Aid	429	658	689	+ 4.7	+ 60.6	+ 4.7
Faculty Compensation	185	284	334	+ 17.6	+ 80.5	+ 17.4
Other	565	1,147†	1,090	− 5.0	+ 92.9	+ 25.6
Current Operations	$1,825	$2,870**	$3,125	+ 8.9	+ 71.2	+ 11.6
Capital Purposes	1,215	1,990*	2,035	+ 2.3	+ 67.4	+ 9.1
Price Indices (1967 = 100)						
Consumer (CPI)	188.5	280.8	293.8	+ 4.6	+ 55.9	
Higher Education (HEPI)	201.3	290.4	308.8	+ 6.3	+ 53.4	

*Includes bequests from Edward Mallinckrodt, Jr., of $77 million to Harvard University and $38 million to Washington University for "other" capital purposes.

**Includes screened film library valued at $30.4 million from Hearst Corporation to University of California at Los Angeles for "other" purposes.

†Includes $15 million in bequests and $30.4 million gift-in-kind.

I call your attention to the fact that support from the business community has grown faster than that from any other source since 1978 and, even when adjusted for inflation, represents a gain of 43 percent over this period. A significant part of this extraordinary growth consists of inventory giving; that is, gifts of products manufactured by the donor companies. This form of giving is now dominated by the computer companies, and the gains are known to be associated with the Economic Recovery Tax Act of 1981 which provided an enhanced deduction for certain contributions of this type of equipment.

The table also shows that about 60 percent of total support was designated for current operations and about 40 percent for capital purposes, including endowment. I regret that our data don't adequately distinguish between gifts for endowment and those for buildings and other physical facilities.

Since the interest of the task force at this hearing is in research infrastructure, I intend to provide a little supplementary data that bears on this interest.

The purposes for which voluntary support is given are shown for two general categories. About 30 percent of the total is not restricted as to purpose by the donors and may, therefore, be allocated by the recipient institutions according to their perceptions of need. Although it becomes comingled with other general funds, some of this money is eventually used for research support.

Among the restricted purposes is the category of research. You will note that an estimated $750 million was given specifically for this purpose in 1983. I will shortly expand on this figure to indicate what information we have as to its source and content.

Some private giving to higher education is restricted to physical plant purposes. You should note the estimate of $791 million. About 10 percent of this money consists of current operating support that is restricted to use in maintaining buildings and other physical facilities. The remaining 90 percent is for capital purposes. This would include some of the research infrastructure, but we have no information as to the exact amounts.

I also call your attention, however, to the category of "other purposes," which now exceeds $1 billion. In fact, the amounts reported in this category in both actual and inflation-adjusted terms have been growing very rapidly during the last 5 years.

Our impression from talking to those in the academic community is that much of this increase consists of support for academic programs, library acquisition, and support of individual departments or schools within the institutions. While we have made some changes in the breakdowns by purpose for our 1984 survey, it is unlikely that we will be able to determine just how much of these miscellaneous grants is going to research support. It is probable, however, that some part—and perhaps a very large part—of the departmental support is used for this purpose.

On page 5, table 2, there are a few significant figures. The last column on the right shows the total support now constitutes only 6.3 percent of the total operating and capital expenditures of all colleges and universities.

Table 2. Voluntary Support in Relation to Enrollment, Inflation and Institutional Expenditures

				Institutional Expenditures			Estimated Voluntary Support			
Year	Total Enrollment (thousands)	Price Indices (1967 = 100) CPI	HEPI	Total (billions)	Per Student (Current)	(CPI)	Total (millions)	Per Student (Current)	(CPI)	As % of Institutional Expenditures
1949-50	2,659	71.7	n.a.	$ 2.5	$ 940	$1,310	$ 240	$ 90	$126	9.6
1965-66	5,967	95.9	95.0	15.2	2,547	2,656	1,440	241	251	9.5
1970-71	8,581	118.8	128.6	26.9	3,135	2,639	1,860	217	183	6.9
1975-76	11,185	165.9	177.2	42.6	3,809	2,296	2,410	215	130	5.6
1980-81	12,097	259.6	263.9	70.5	5,828	2,245	4,230	350	135	6.2
1982-83	12,358	293.8	308.8	82.5	6,676	2,272	5,160	418	142	6.3
Average Annual Percentage Change:										
1949-50 to 1965-66	5.2	1.8	n.a.	11.9	6.4	4.5	11.9	6.4	4.4	
1965-66 to 1970-71	7.5	4.4	6.2	12.1	4.2	−0.1	5.3	−2.0	−6.1	
1970-71 to 1975-76	5.4	6.9	6.6	9.6	4.0	−2.7	5.3	−0.2	−6.6	
1975-76 to 1980-81	1.6	9.4	8.1	10.6	15.7	−0.4	11.9	10.2	0.8	
1980-81 to 1982-83	1.1	6.4	8.2	8.2	7.0	0.6	10.4	9.3	2.6	

Historically, this percentage has been higher than this. For example, as recently as the mid-1960's it was about 10 percent. It fell slowly to less than 6 percent in the mid-seventies and has been on a slight up trend.

Throughout the period for which we have these data, voluntary support has risen much faster than the rate of inflation. This is true whether inflation is measured by the Consumer Price Index, or the CPI, or the Higher Education Price Index, HEPI. It has also risen faster than the number of students, and support per student is shown to be now more than four times what it was in 1950. However, since the mid-1960's the growth of private giving has been slower than the combined effects of inflation and enrollment growth, so that support per student measured in constant dollars is now 40 percent less than it was in 1966.

There has also been a decline in institutional expenditures per student, measured in constant dollars. We take these facts to support the view that there has been some decline in the quality of higher education that has probably affected both instruction and research.

At the back of the report are several summaries and historical tables of data. On page 72, table E gives our estimates of voluntary support with a breakdown between current and capital money and the distribution by sources for all years since 1950.

Table E ESTIMATED TOTAL VOLUNTARY SUPPORT OF HIGHER EDUCATION BY MAJOR PURPOSE AND TYPE OF DONOR, 1949-50 TO 1982-83

(Millions of dollars)

Year	Total Voluntary Support	Current Operations	Capital Purposes	Individuals		Foundations	Business Corporations	Religious Denominations	Other
				Alumni	Nonalumni				
1949-50	$ 240	$ 101	$ 139	$ 60	$ 60	$ 60	$ 28	$ 16	$ 18
1950-51	260	107	153	64	64	68	30	19	21
1951-52	297	129	168	72	72	72	40	20	21
1952-53	350	161	189	85	85	85	50	23	23
1953-54	394	184	210	90	90	90	60	34	30
1954-55	475	200	275	111	119	83	95	43	55
1955-56	575	235	340	118	148	180	78	57	63
1956-57	840*	290	550*	130	150	346*	87	63	65
1957-58	715	325	390	180	180	135	60	75	73
1958-59	760	417	343	186	186	107	119	78	84
1959-60	815	385	430	161	164	163	130	80	57
1960-61	900	400	500	166	205	210	147	82	54
1961-62	950	415	535	220	210	230	134	88	54
1962-63	1,080	535	545	234	227	248	160	95	62
1963-64	1,215	540	675	265	256	280	181	97	68
1964-65	1,400	610	790	280	348	408	196	101	73
1965-66	1,440	675	765	310	350	387	230	108	85
1966-67	1,480	710	770	364	373	337	240	107	80
1967-68	1,600	800	800	390	406	374	250	118	91
1968-69	1,800	870	930	434	458	434	273	100	106
1969-70	1,780	960	820	381	441	434	260	102	153
1970-71	1,860	1,050	810	436	465	418	230	104	136
1971-72	2,020	1,110	910	481	483	523	275	101	147
1972-73	2,240	1,230	1,010	536	600	584	330	99	161
1973-74	2,240	1,300	940	530	556	535	354	116	170
1974-75	2,160	1,370	790	490	518	487	357	112	192
1975-76	2,410	1,480	930	588	580	549	379	130	185
1976-77	2,670	1,620	1,050	636	648	558	446	136	246
1977-78	3,040	1,825	1,215	714	706	683	508	158	271
1978-79	3,230	2,010	1,220	785	736	701	556	161	291
1979-80	3,800**	2,220	1,580**	910	847	903**	696	155	289
1980-81	4,230	2,390	1,840	1,040	1,037	921	778	140	334
1981-82	4,860†	2,870†	1,990†	1,340†	1,007	1,003	976†	175	369
1982-83	5,160	3,125	2,035	1,237	1,190	1,018	1,112	206	397

*Includes approximately $200 million of faculty salary endowment grants.

**Includes $105 million nonrecurring transfer for unrestricted endowment. (See Appendix Table C.)

†Includes $115 million in bequests from alumni for capital purposes and $30.4 million gift-in-kind from corporations for current operations.

There are two points worth noting. Support for capital purposes, which would include research infrastructure, typically exceeded support for current operations until about 1970. Since then, operating support has consistently accounted for the larger share. The distribution of total support by sources displayed an extraordinary stability. The gifts and bequests from individuals have consistently accounted for about half of the total, with roughly equal shares from alumni and nonalumni donors.

The only major trends are a generally declining share from religious denominations, some decrease in the share of private foundations since 1969, and a significant increase in the proportion of the total that comes from business corporations. We expect these trends more or less to continue.

The remainder of the tabular material in this report represents not our estimates of the total for all higher education, but the amounts actually reported by the participating institutions.

Let me skip down and just call your attention to one of these tables, which is table C on page 70, which is a distribution of reported support by type of institution.

Table C VOLUNTARY SUPPORT OF HIGHER EDUCATION BY TYPE OF INSTITUTION

(Including percentage of Grand Total and average per institution; dollar totals and averages in thousands)

TYPE OF INSTITUTION*	1973-1974	1974-1975	1975-1976	1976-1977	1977-1978
Private Universities	$701,160 (40.2%) (68) Av. $10,311	$648,477 (38.7%) (69) Av. $ 9,398	$731,914 (38.7%) (71) Av. $10,309	$804,997 (37.8%) (73) Av. $11,027	$877,122 (37.4%) (69) Av. $12,712
Private Men's Colleges	26,671 (1.5%) (14) Av. $ 1,905	17,860 (1.0%) (13) Av. $ 1,373	24,852 (1.3%) (16) Av. $ 1,553	20,337 (1.0%) (11) Av. $ 1,849	28,325 (1.2%) (9) Av. $ 3,147
Private Women's Colleges	68,291 (3.9%) (78) Av. $ 875	64,469 (3.8%) (80) Av. $ 806	74,422 (4.0%) (81) Av. $ 919	71,898 (3.4%) (69) Av. $ 1,042	80,723 (3.4%) (80) Av. $ 1,009
Private Coed Colleges	461,117 (26.4%) (463) Av. $ 996	426,579 (25.5%) (453) Av. $ 941	470,983 (24.9%) (448) Av. $ 1,051	571,410 (26.7%) (476) Av. $ 1,200	620,795 (26.4%) (459) Av. $ 1,352
Professional & Specialized	84,365 (4.8%) (51) Av. $ 1,654	69,327 (4.1%) (54) Av. $ 1,283	93,036 (4.9%) (55) Av. $ 1,692	89,475 (4.2%) (59) Av. $ 1,517	94,651 (4.0%) (61) Av. $ 1,552
Public Institutions	386,161 (22.1%) (206) Av. $ 1,874	430,831 (25.8%) (207) Av. $ 2,081	476,915 (25.2%) (216) Av. $ 2,208	562,405 (26.3%) (213) Av. $ 2,640	623,444 (26.6%) (209) Av. $ 2,983
Two-Year Institutions	19,066 (1.1%) (108) Av. $ 176	17,009 (1.0%) (110) Av. $ 154	18,709 (1.0%) (104) Av. $ 180	18,137 (0.8%) (105) Av. $ 173	22,865 (1.0%) (178) Av. $ 128
GRAND TOTAL	$1,746,851 (100%) (988) Av. $1,768	$1,674,543 (100%) (986) Av. $1,698	$1,890,832 (100%) (991) Av. $1,908	$2,138,687 (100%) (1,006) Av. $2,126	$2,347,925 (100%) (1,065) Av. $2,205

TYPE OF INSTITUTION*	1978-1979	1979-1980	1980-1981	1981-1982	1982-1983
Private Universities	$1,001,866 (39.2%) (73) Av. $13,724	$1,202,420 (39.4%)** (74) Av. $16,249	$1,328,044 (40.0%) (75) Av. $17,707	$1,513,497 (37.0%)† (74) Av. $20,453	$1,530,598 (35.0%) (73) Av. $20,967
Private Men's Colleges	20,230 (0.8%) (6) Av. $ 3,372	16,158 (0.5%) (7) Av. $ 2,308	14,680 (0.4%) (5) Av. $ 2,936	20,808 (0.5%) (7) Av. $ 2,972	20,438 (0.4%) (9) Av. $ 2,271
Private Women's Colleges	80,856 (3.2%) (73) Av. $ 1,108	97,548 (3.2%) (74) Av. $ 1,318	118,947 (3.6%) (73) Av. $ 1,629	127,333 (3.1%) (77) Av. $ 1,654	155,421 (3.6%) (77) Av. $ 2,018
Private Coed Colleges	624,425 (24.4%) (449) Av. $ 1,391	732,832 (24.0%) (473) Av. $ 1,549	784,468 (23.7%) (440) Av. $ 1,783	1,018,482 (24.9%) (496) Av. $ 2,053	1,075,872 (24.6%) (495) Av. $ 2,173
Professional & Specialized	95,297 (3.7%) (67) Av. $ 1,422	128,104 (4.2%) (68) Av. $ 1,884	121,276 (3.7%) (62) Av. $ 1,956	155,347 (3.8%) (73) Av. $ 2,128	185,809 (4.3%) (90) Av. $ 2,065
Public Institutions	715,156 (28.0%) (214) Av. $ 3,342	856,193 (28.0%) (218) Av. $ 3,927	929,236 (28.0%) (209) Av. $ 4,446	1,216,681 (29.9%)§ (258) Av. $ 4,716	1,362,397 (31.2%) (267) Av. $ 5,103
Two-Year Institutions	18,173 (0.7%) (90) Av. $ 202	21,797 (0.7%) (109) Av. $ 200	21,413 (0.6%) (64) Av. $ 334	34,060 (0.8%) (116) Av. $ 294	37,643 (0.9%) (126) Av. $ 299
GRAND TOTAL	$2,555,996 (100%) (972) Av. $2,630	$3,055,053 (100%) (1,019) Av. $2,998	$3,318,064 (100%) (928) Av. $3,576	$4,086,204 (100%) (1,101) Av. $3,711	$4,368,171 (100%) (1,137) Av. $3,842

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*In every survey each institution is classified in the category appropriate to its status in that year. Since the status of many institutions has changed over the years, the data by category are not strictly comparable from one survey to another. See Table 3 on page 7 for a comparison of 1981-82 and 1982-83 data on an adjusted basis.

**Includes nonrecurring transfer of $105 million.

†Includes $115 million in bequests.

§Includes $30.4 million gift-in-kind.

A group of 70 or 75 private universities consistently accounts for between 35 and 40 percent of the total received by all institutions, but the most significant change on this table in terms of institutional shares is the growth of public colleges and universities from about 22 percent of the total to 31 percent over this particular period of time, and a declining share received by the categories of smaller private colleges.

All this information is stored on computer tapes since 1966, and it is possible to prepare special tabulations and analyses of these data to serve particular purposes. In order to address the specific subject of this hearing, I prepared a few supplementary tables and they are appended to the statement itself.

Table 1, for example, shows the preliminary figures from our 1983-84 survey and the estimated $5.6 billion in total support is broken down by source. I am sorry that we do not have figures yet for a breakdown by purpose.

Table 1. Estimated Voluntary Support, by Source and Purpose (millions)

				Percent change, 1983-84		
	1978-79	1982-83	1983-84	v.1982-83	v.1978-79	v.1978-79 adj. for HEPI
TOTAL VOLUNTARY SUPPORT	$3,230	$5,160	$5,600	+ 8.5	+73.4	+15.6
Sources:						
Alumni	$ 785	$1,237	$1,305	+ 5.4	+66.2	+10.8
Nonalumni individuals	736	1,190	1,316	+10.6	+78.8	+19.2
Foundations	701	1,018	1,081	+ 6.2	+54.2	+ 2.8
Business Corporations	556	1,112	1,271	+14.3	+128.6	+52.7
Religious Organizations	161	206	190	- 7.8	+18.0	-21.6
Other	291	397	437	+10.1	+50.2	-
Purposes:						
Current Operations	$2,010	$3,125	$3,405	+ 9.0	+69.4	+12.8
Capital Purposes	1,220	2,035	2,195	+ 7.9	+79.9	+20.1
Price Indices (1967-100):						
Consumer (CPI)	206.4	293.8	304.8	+ 3.7	+47.7	
Higher Education (HEPI)	216.9	308.8	325.4	+ 5.4	+50.0	

The results do reflect a continuation of current trends or recent trends. Again, I call your attention to the fact that support from business corporations has shown an extraordinary increase in inflation-adjusted terms over the previous 5 years. Much of this growth, perhaps as much as $250 million, is associated with the addition of section 170(e)(4) to the Internal Revenue Code. This is the section that provides the enhanced tax deduction in the case of inventory gifts of scientific property that are made to institutions of higher education to be used for research or experimentation or for research training in the physical or biological sciences.

To throw some light on this matter, we conducted a survey of the leading industrial corporations last fall. Our report on that survey is available as well. I have provided copies to the task force.

Although the response to this particular survey was relatively low, the data we did obtain reveals clearly that this type of giving is dominated by companies in the electrical machinery industry, especially the companies that manufacture computers, medical instruments, and other electronic products. That is shown on the table on page 2 of the special survey report.

Gifts of Company Products

Industry	1983	1984
Manufacturing:		
Electrical machinery (21)	$61,729,490 (19)	$95,281,540 (14)
Chemicals & drugs (6)	13,910,196 (3)	167,917 (3)
Food, beverage & tobacco (4)	32,939 (3)	36,420 (3)
Machinery (4)	480,000 (3)	311,700 (3)
Fabricated metals (3)	32,800 (3)	252,000 (3)
Primary metals (3)	3,818 (1)	1,000 (1)
Paper & lumber (3)	1,500 (1)	11,800 (1)
Printing & publishing (2)	41,485 (2)	33,809 (2)
Petroleum & gas (2)	12,500 (2)	13,500 (2)
Transportation equipment (1)	25,000 (1)	---
Subtotal - Manufacturing (49)	$76,269,728 (38)	$96,109,286 (32)
Nonmanufacturing:		
Transportation (2)	$ 40,403 (2)	$ 45,000 (1)
All others (3)	300 (1)	500 (1)
Subtotal - Nonmanufacturing (5)	$ 40,703 (3)	$ 45,500 (2)
GRAND TOTAL (54)	$76,310,431 (41)	$96,155,186 (34)

(Numbers in parentheses show the number of companies reporting.)

I should also call to your attention that the numbers shown on this report reflect a tax deduction value of the gifts to the donors. The colleges and universities report a significantly higher figure because they tend to report the list price value.

It is my personal view that this enhanced deduction should be extended to all inventory gifts of company products and not limited to any class of qualified recipients or to any designated purposes. The formula used for the tax reduction adequately protects the public interest in preventing the kinds of abuses that led to the restrictive legislation in the Tax Reform Act of 1969. It would clearly provide additional incentives for contributions of state-of-the-art equipment to the scientific laboratories on the Nation's campuses as well as a broad array of other products that are useful and needed by charities generally.

Table 2, the supplementary table attached to the statement, gives a breakdown of the research support by donor groups taken from the surveys of 1973 and 1983. This type of support is shown to be of relatively little interest to individual givers, and what they do give accounts for a very small share of the total support. Contributions for research purposes are clearly a major growing interest to corporations and foundations, and between them they account for about 70 percent of the total.

Table 2. Voluntary Support for Research Purposes, by Donor Groups (millions)

	1972-73			1982-83		
	Amount	%	Percent of total support	Amount	%	Percent of total support
Alumni	$ 13.3	5.8	3.2	$ 24.8	3.9	2.4
Nonalumni Individuals	37.6	16.3	8.0	77.2	12.2	7.7
Foundations	89.0	38.6	21.7	207.4	32.7	24.1
Business Corporations	53.9	23.4	21.6	232.0	36.6	24.6
Religious Organizations	.1	-	.1	.4	-	.3
Other	36.9	16.0	29.3	92.9	14.6	27.7
	$230.8	100.0	13.2	$634.7	100.0	14.5

Table 3 shows the sources of total support, research support, and physical plant support for 1983 with a division between current operating support and support for capital purposes. While capital support accounts for about 42 percent of overall giving, it comprises only 9 percent of giving for research purposes. The bulk of research support obviously goes for institutional operating budgets.

Table 3. Total Voluntary Support, Research Support, and Support for Physical Plant, by Purpose (Current Operations and Capital Purposes), 1982-83 (millions)

	Total Voluntary Support			Research Support			Support for Physical Plant		
	Total	Cur.	Cap.	Total	Cur.	Cap.	Total	Cur.	Cap.
Alumni	$1,046.9	$ 503.8	$ 543.1	$ 24.8	$ 18.0	$ 6.8	$132.5	$ 7.8	$124.7
Nonalumni Inds.	1,007.2	450.5	556.7	77.2	48.6	28.6	153.3	11.3	142.0
Foundations	862.1	497.2	364.9	207.4	198.2	9.2	177.9	14.3	163.6
Corportions	941.6	662.4	279.2	232.0	222.7	9.3	167.0	16.0	151.0
Religious Orgns.	174.4	150.2	24.2	.4	.1	.3	16.1	2.6	13.5
Other	335.9	260.3	75.6	92.9	90.1	2.8	22.6	3.4	19.2
Total	$4,368.1	$2,524.4	$1,843.7	$643.7	$577.7	$ 57.0	$669.4	$ 55.4	$614.0

On the physical plant side, however, it was 92 percent capital, and some part of that $614 million of capital support for physical plant purposes was undoubtedly aimed at the kind of research infrastructure in which this task force is interested, although we do not have any specific information as to exactly how much.

Table 4 gives an historical overview of estimated research support and shows the percentage of research to estimated total support for all purposes. You will note that there is a modest up trend in this percentage. Prior to 1975, for example, it averaged 12.8, and in no year was it as high as 15 percent. In the last 10 years, however, it has averaged 15 percent, and in no year was it less than 13.9.

Table 4. Estimated Voluntary Support and Support of Research, 1954-55 to 1983-84

	Total Voluntary Support	Support of Research	%
1954-55	$ 475	$ 60	12.5
1956-57	840	85	9.9
1958-59	760	105	14.0
1960-61	900	125	14.1
1962-63	1,050	140	13.4
1964-65	1,400	155	11.2
1965-66	1,440	205	14.4
1966-67	1,480	185	12.4
1967-68	1,600	200	12.5
1968-69	1,800	225	12.5
1969-70	1,780	215	12.1
1970-71	1,860	245	13.3
1971-72	2,020	260	12.8
1972-73	2,240	290	13.0
1973-74	2,240	290	13.0
1974-75	2,160	325	15.0
1975-76	2,410	355	14.7
1976-77	2,670	400	14.9
1977-78	3,040	475	15.7
1978-79	3,230	505	15.7
1979-80	3,800	575	15.1
1980-81	4,230	630	14.9
1981-82	4,860	675	13.9
1982-83	5,160	750	14.5
1983-84	5,600	840	15.0 (est.)

While prediction is always hazardous, I believe that there are reasons to anticipate further growths in this percentage. One reason is the growing relative importance of corporate support in the total picture. In the past 15 years the percentage of corporate giving to total support has increased from less than 15 to more than 22 percent, and it is still rising. Since a high proportion of corporate support is designated for research purposes, continued growth in the relative importance of corporate giving will cause some further rise in the overall importance of research support. The second reason is that there has been, and continues to be, a growing sense of partnership between the corporation and the campus, especially in the research area. The universities are now making special efforts to enhance further this community of interest.

Table 5 gives some detail of corporate support and corporate support of research by type of institution in 1982–83. The most relevant figures here are those which show the relative importance of the public and private institutions. Although the corporations give more to private institutions than to public colleges and universities, the proportion of support designated for research purposes at public institutions has more than doubled the corresponding number for private colleges and universities.

Table 5. Corporate Support of Colleges and Universities and Corporate Support of Research, by Type of Institution, 1982-83 (millions)

	Total Corporate Support	Corporate Research Support	%
Private Universities (73)	$ 334.1	$ 74.3	22.2
Private Men's Colleges (9)	1.5	-	-
Private Women's Colleges (77)	13.4	.2	-
Private Coeducational Colleges (495)	127.9	1.9	1.5
Private Professional & Specialized Insts. (90)	27.9	6.2	22.2
Total Private Four-Year Institutions (744)	$ 504.8	$ 82.7	16.3
Total Public Four-Year Institutions (267)	428.6	149.3	34.8
Total Four-Year Institutions (1,011)	$ 933.4	$ 232.0	24.8
Two-Year Institutions (126)	8.2	-	-
Grand Total, All Institutions (1137)	$ 941.6	$ 232.0	24.6

Note: Numbers in parentheses are numbers of participating institutions.

You should note that the division of corporate support at 4-year institutions between public and private colleges is now in the ratio of about 46 to 54. Twenty-five years ago the ratio was 25 to 75, and this shift reflects a long-term trend of growing importance—it reflects the growing importance of public research in universities to the business community. Given that the corporate support of public institutions is growing more rapidly than that for private colleges, and given the relatively greater importance of research support in public institutions, it also follows that a continuation of these trends will invariably raise research support as a percentage of total giving by corporations.

Over and above the gifts and grants that corporations provide to the colleges and universities for research purposes are two other forms of research support from business. One is contract research in which the university performs specific research of a proprietary or quasi-proprietary nature as a quid pro quo for the money it receives under the contract. The second covers a variety of cooperative research projects, and these are typically informal arrangements under which one or more persons on the corporate side join with their academic counterparts to pursue a specific line of inquiry. The corporation will often loan or donate equipment to, and pay the out-of-pocket costs of, such projects. In both these cases, of course, our numbers exclude the corporate money received by the institution.

The growth of all these related shifts in the past 3 or 4 years has undoubtedly been stimulated by the provisions of the Economic Tax Recovery Act of 1981 which added section 30 to the Internal Revenue Code, and this is the 25 percent credit for increasing research activities, which will expire or sunset at the end of this year. The success of this legislation in accomplishing its purposes—namely, to increase corporate research and development activities—and the desirability of increasing such activities further indicate the need for making this section to become permanent. In view of the fact that the credit now applies to 65 percent of any incremental contract research expenditures, including contract research at universities, it would be most unfortunate if this section were allowed to expire. Indeed, the credit should be renewed at a higher percentage, even 100 percent, of the contract research on campus eligible for this 25 percent credit.

I have a final word about public policy in this whole area of private giving to higher education. Educational support is part of the total charitable contributions from individuals, corporations, and foundations. The basic motivation for making contributions has little or nothing to do with the tax laws; people and corporations give for reasons that are independent of taxation. However, once the decision to give has been made, the charitable deduction does have an influence on the amount that is given. While this is theoretically true for all individuals, it is particularly true for those in the upper tax brackets.

The relevance of this to the purpose of this hearing is that private contributions for research and for research infrastructure at universities in the future will depend greatly on the content of the tax laws with respect to the charitable deduction. Any simplification of the income tax involving the reduction of marginal rates will indirectly tend to reduce the amounts that people and corporations give, simply because it would increase the after-tax cost of contributions. Since there is a valid objective to be served by such rate reduction, then the indirect impact on charitable giving is simply a burden that will have to be borne.

However, there have been specific proposals for altering the charitable deduction itself, and these would have additional and direct negative effects on giving, including research support to higher education. One proposal would put a floor on the deduction, so that only contributions in excess of some specific dollar amount or some percentage of income would be deductible. Another proposal would limit the deduction for gifts of property to the lower of cost or inflation-adjusted cost, and deny any deduction for capital appreciation in such gift property. A third proposal would eliminate the present provision for an above-the-line deduction for nonitemizers. All three of these proposals, taken together, would seriously erode the present levels of charitable giving in general and support of higher education in particular.

I would hope that the members of this task force will conclude that private support of research and of research infrastructure at universities, although small in relation to support by Government in recent years, is a necessary, desirable, and vital activity, to be encouraged to the maximum reasonable extent. And should any of the above tax proposals become part of a tax simplification bill, I would hope that the members of this task force will oppose those proposals as contrary to the public interest.

This concludes my prepared statement. If there are any questions or needs for amplification of any of the above facts, I will be happy to try to provide the answers.

Mr. FUQUA. Thank you very much, Mr. Smith.

[The prepared statement of Mr. Smith follows:]

PRIVATE SUPPORT OF RESEARCH AT COLLEGES AND UNIVERSITIES

Testimony of

Hayden W. Smith

Senior Vice President
Council for Financial Aid to Education
680 Fifth Avenue
New York, New York 10019

Task Force on Science Policy
Committee on Science and Technology
U.S. House of Representatives

May 22, 1985

PRIVATE SUPPORT OF RESEARCH AT COLLEGES AND UNIVERSITIES

Hayden W. Smith

Senior Vice President
Council for Financial Aid to Education
680 Fifth Avenue
New York, New York 10019

My name is Hayden W. Smith. I am senior vice president of the Council for Financial Aid to Education, located in New York City. The Council is known throughout the corporate and academic communities by its initials, CFAE, and I shall use them here.

CFAE is a nonprofit service agency created in 1952 by eminent corporate leaders. Its purpose is to encourage the widest possible support of higher education by private donors, especially the corporate community itself. It is supported exclusively by voluntary contributions from some 400 business corporations. Its program consists of research, publications, and consultation with business executives to encourage corporate support of higher education. It is best known to the country at large through a public service advertising campaign that uses the well-known slogan, "Give to the College of Your Choice."

I am appearing here today to provide the Task Force with information on the extent to which private donors, including individuals, industrial firms, and foundations, have supported the acquisition and maintenance of the research infrastructure at American universities. I intend also to comment on current and future trends in this type of support, and to discuss several elements of federal fiscal policy that impinge on donors' incentives.

Among the research activities for which CFAE is well known is the annual Survey of Voluntary Support of Education. We are the only agency that gathers such data and we are the leading authority on this type of information. I have previously furnished copies of our latest survey report to the Task Force, and will comment on its contents as they bear on the purpose of this hearing.

The report before you covers the academic year 1982-83. This represents the 24th survey of private giving to education that we have conducted since 1955. The survey has been an annual undertaking since 1965, and is now cosponsored by the Council for Advancement and Support of Education and the National Association of Independent Schools. Although it includes data on private support of private precollege schools, I will exclude them from our discussion today.

The survey questionnaires are mailed to virtually all of the 3,000 institutions of higher education in the United States. The information requested includes the amounts, sources, and purposes of private gifts, grants, and bequests received during the previous academic or fiscal year. We specifically request the exclusion of pledges, endowment income, and any receipts which represent payment for services rendered. While we cannot guarantee the accuracy of the figures provided, we have no reason to believe that they contain any significant errors.

The response rate varies from year to year but generally amounts to 35 percent. On the basis of careful comparisons with financial data previously gathered by the U.S. Office of Education (now the Department of Education), it is clear that those institutions participating in the survey typically account for about 85 percent of the total dollars received by all colleges and universities. The nonparticipating institutions are primarily two-year colleges, the smaller state colleges and universities, and very specialized private schools such as religious seminaries and bible colleges, most of which receive little or no voluntary support.

If you will turn to page 3 of the 1982-83 report you will find charts which depict our estimates of voluntary support of higher education for the previous decade. These estimates are prepared from the survey findings by means of a careful analysis of the reported data, taking into account the relative importance of different kinds of institutions and the differential response rates.

The chart on the left shows that total voluntary support rose from $2.16 billion in 1974-75, which was a recession year, to $5.16 billion in 1982-83. Although we do not yet have a complete analysis of the data from the 1983-84 survey, there is enough information off the computer to permit an estimate of $5.6 billion. This implies that private giving to higher education has increased at an average rate of 11.2 percent per year over the last nine years which, when corrected for inflation, represents a real growth of about 3.5 percent annually.

Table 1 on page 4 gives breakdowns of our estimate by source and by purpose. Individual donors account for roughly half of all voluntary support, and the dollars are divided about equally between institutional alumni and other individuals.

Business corporations and private foundations each account for about one-fifth of the total; the remainder comes from religious denominations and a variety of other sources. I call your attention to the fact that support from the business community has grown faster than that from any other source since 1977-78, and even when adjusted for inflation represents a gain of 43 percent over this period. A significant part of this extraordinary growth consists of inventory giving, i.e. gifts of products manufactured by the donor companies. This form of giving is now dominated by the computer companies, and the gains are known to be associated with the Economic Recovery Tax Act of 1981 which provided an enhanced deduction for certain contributions of this type of equipment.

The table also shows that about 60 percent of total voluntary support was designated for current operations and 40 percent for capital purposes, including endowment. I regret that our data do not adequately distinguish between gifts for endowment and those for buildings and other physical facilities. Since the interest of the Task Force at this hearing is in research infrastructure, I intend to provide some supplementary data that bears on this interest.

The purposes for which voluntary support is given are shown for a few general categories. About 30 percent of the total is not restricted as to purpose by the donors and may, therefore, be allocated by the recipient institutions according to their perceptions of need. Although it becomes comingled with other general funds, some of this money is eventually used for research support. Among the restricted purposes is the category of research, and you will note that an estimated $750 million was given specifically for this purpose in 1982-83. I will shortly expand on this figure to indicate what information we have as to its source and content.

Some private giving to higher education is restricted to physical plant purposes, and you should note the estimate of $791 million. About ten percent of this money constitutes current operating support that is restricted to use in maintaining buildings and other physical facilities; the remaining 90 percent is for capital purposes. This would include some research infrastructure, but we have no information as to the amounts.

I also call your attention to the category of "other" purposes, which now exceeds $1 billion, and to the fact that the amounts reported in this category in both actual and inflation-adjusted terms have been growing very rapidly in the past five years. Our impression from talking to those in the academic community is that much of this increase constitutes support of academic programs, library acquisitions, and support of individual departments or schools within the institutions. While we have made some changes in the breakdowns by purpose for the 1983-84 survey, it is unlikely that we will be able to determine how much of these miscellaneous grants is going for research purposes. It is probable, however, that some part, and perhaps a large part, of the departmental support is used for this purpose.

There are a few significant figures in Table 2 on page 5. The last column on the right shows that total voluntary support now constitutes only 6.3 percent of the total operating and capital expenditures of all colleges and universities. Historically this percentage has been higher than this; for example, as recently as the mid-1960s it was about ten percent, then it fell slowly to less than six percent in the mid-1970s, and it has since been in a slight uptrend.

Throughout the period for which we have these data, voluntary support has risen much faster than the rate of inflation, and this is true whether inflation is measured by the Consumer Price Index (CPI) or the Higher Education Price Index (HEPI). It has also risen faster than the number of students, and support per student is now more than four times what is was in 1950. However, since the mid-1960s the growth of private giving has been slower than the combined effects of inflation and enrollment growth, so that support per student measured in constant dollars is now 40 percent less than it was in 1966. There has also been a decline in institutional expenditures per student, measured in constant dollars, and we take these facts to support the view that there has been some decline in quality in higher education that has probably affected both instruction and research.

At the back of the report are several summary and historical tables of data. On page 72, Table E gives our estimates of voluntary support, with a breakdown between current and capital money and the distribution by source, for all years since 1950. There are two points worth noting. Support for capital purposes typically exceeded support for current operations until 1970; since then operating support has consistently accounted for the larger share. And the distribution of total support by source has displayed an extraordinary stability; the gifts and bequests from individuals have consistently accounted for about half of the total, with roughly equal shares from alumni and nonalumni donors; the only major trends are a generally declining share from religious denominations, some decrease in the share of foundations since 1969 and a significant increase in the proportion of the total that comes from business corporations.

The remainder of the tabular material in this report represents not our estimates for all higher education but amounts actually reported by the participating institutions. Of special interest to this Task Force is the bottom half of Table D on page 71. The amounts reported over the last ten years have shown remarkable stability in terms of purpose; there has been a decline in unrestricted money from about 33 percent to 29 percent and a corresponding increase in the "other" category from 17 to 21 percent; support for physical plant and for research each account for about 15 or 16 percent every year, student aid has been relatively constant at 13 percent, and faculty compensation at about 6 percent.

Finally, I call your attention to Table C on page 70, which shows that a group of 70 or 75 private universities consistently accounts for between 35 and 40 percent of the total support received by all institutions. The most significant change in the institutional shares is a growth for the public colleges and universities from 22 to 31 percent of the total and a corresponding decline in the shares received by the four categories of smaller private colleges.

All this information has been stored on computer tape since 1966, and it is possible to prepare special tabulations and analyses of these data to serve particular purposes as needed. In order to address the specific subject of this hearing, we have prepared a few supplementary tables, and they are appended to this statement.

Table 1 shows the preliminary figures from the 1983-84 survey. The estimated $5.60 billion of total support is broken down by source, and the results reflect a continuation of recent trends. Again I call your attention to the fact that support from business corporations has shown an extraordinary increase in inflation-adjusted terms over the previous five years. Much of this growth, perhaps as much as $250 million, is associated with the addition of section 170(e)(4) to the Internal Revenue Code. This section provides for an enhanced tax deduction in the case of inventory gifts of scientific property that are made to institutions of higher education and to be used for research or experimentation or for research training in the physical or biological sciences.

To throw some light on this matter, we conducted a survey of the leading industrial corporations last year, and our report on that survey is available to this Task Force. Although the response rate was relatively low, the data we did obtain reveals clearly that this type of giving is dominated by the companies in the electrical machinery industry, especially companies that manufacture computers, medical instruments, and other electronic products. The numbers shown on page 2 of that report reflect the tax-deduction value of the gifts made, and this figure is significantly lower than the list price value used by recipient institutions in our voluntary support survey.

It is my personal view that this enhanced deduction should be extended to all inventory gifts of company products and not limited to any class of qualified recipients or to any designated purposes. The formula used for the tax deduction adequately protects the public interest in preventing the kinds of abuses that led to the restrictive legislation in the Tax Reform Act of 1969, and it would clearly provide additional incentives for contributions of state-of-the-art equipment to the scientific laboratories on the Nation's campuses as well as a broad array of other products that are useful and needed by charities generally.

The second supplementary table attached to this statement gives a breakdown of research support by donor groups taken from our voluntary support surveys of 1972-73 and 1982-83. This type of support is of relatively little interest to individual givers, and what they do give accounts for a small share of the total. Contributions for research purposes are clearly of major and growing interest to corporations and foundations, and they account for about 70 percent of the total.

Table 3 shows the sources of total support, research support, and physical plant support in 1982-83 with the division between current operating support and support for capital purposes. While capital support accounted for 42 percent of overall giving, it comprised only 9 percent of giving for research purposes. The bulk of research support obviously goes for institutional operating budgets. Physical plant support, on the other hand, was 92 percent capital. Some part of the $614 million reported in the survey was undoubtedly aimed at the kinds of research infrastructure in which this Task Force is interested, but we do not have any information as to how much.

Table 4 gives an historical overview of estimated research support and shows the percentage of research support to estimated total support for all purposes. There is a very modest uptrend in this percentage. Prior to 1974-75 it averaged about 12.8 and in no year was it as high as 15.0; in the last ten years it has averaged 15.0 and in no year was it less than 13.9.

While prediction is always hazardous, I believe there are reasons to anticipate further modest growth in this percentage. One reason is the growing relative importance of corporate support in the total picture; in the past 15 years the percentage of corporate giving to total voluntary support has increased from less than 15 percent to more than 22 percent and it is still rising. Since a high proportion of corporate support is designated for research purposes, continued growth in the relative importance of corporate support will cause some further rise in the relative overall importance of research support. A second reason is that there has been, and continues to be, a growing sense of partnership between the corporation and the campus, especially in the research area, and universities are making special efforts to enhance further this community of interest.

Table 5 gives some detail of total corporate support and corporate support of research by type of institution in 1982-83. The most relevant figures here are those which show the relative importance of public and private institutions. Although corporations give more to private institutions than to public colleges and universities, the proportion of support designated for research purposes at public institutions is more than double the corresponding number for private colleges and universities.

Please note that the division of corporate support of four-year institutions between public and private colleges is in the ratio of 46-to-54; 25 years ago the ratio was 25-to-75, and this shift reflects a long-term trend of growing importance of public research universities to the business sector.

Given that corporate support for public institutions is growing more rapidly than that for private colleges and universities, and given the relatively greater importance of research support at public institutions, if follows that a continuation of these trends will invariably raise research support as a percentage of total corporate support of higher education.

Over and above the gifts and grants that corporations provide to colleges and universities for research purposes, there are two other forms of research support from business. One is contract research, in which the univesity performs specific research of a proprietory or quasi-proprietory nature as a quid pro quo for the money it receives under the contract. The second covers a variety of cooperative research projects. These are typically informal arrangements under which one or more persons on the corporate side join with their academic counterparts to pursue a specific line of inquiry; the corporation will often loan or donate equipment to, and pay the out-of-pocket costs of, such projects. In both these cases, of course, our numbers exclude the corporate money received by the institution.

The growth of these relationships in the past three or four years has undoubtedly been stimulated by the provision in the Economic Recovery Tax Act of 1981 which added section 30 to the Internal Revenue Code. This is the 25 percent credit for increasing research activities, and it will expire or "sunset" at the end of this year. The success of this legislation in accomplishing its purposes, namely to increase corporate research and development activities, and the desirabliity of increasing such activities further, indicates the need for making this section of the Code permanent. And, in view of the fact that the credit now applies to 65 percent of any incremental contract research expenditures, including contract research at universities, it would be most unfortunate if this section were allowed to expire. Indeed, the credit should be renewed and a higher percentage -- even 100 percent -- of contract research on campus should be made eligible for the 25 percent credit.

A final word on public policy in the area of private giving to higher education. Educational support is a part of total charitable contributions from individuals, corporations and foundations. The basic motivation for making contributions has little or nothing to do with the tax laws; people and corporations give for reasons that are independent of taxation. However, once the decision to give has been made, the charitable deduction does have an influence on the amount that is given. While this is theoretically true for all individuals, it is particularly true for those in the upper tax brackets.

The relevance of this to the purpose of this hearing is that private contributions for research and for research infrastructure at universities in the future will depend greatly on the content of the tax laws with respect to the charitable deduction. Any simplification of the income tax involving the reduction of marginal rates will indirectly tend to reduce the amounts that people and corporations give, simply because it would increase the after-tax cost of contributions. Since there is a valid objective to be served by such rate reduction, then the indirect impact on charitable giving is simply a burden that will have to be borne.

However, there have been specific proposals for altering the charitable deduction itself, and these would have additional and direct negative effects on giving, including research support to higher education. One proposal would put a floor on the deduction, so that only contributions in excess of some specific dollar amount or some percentage of income would be deductible. Another proposal would limit the deduction for gifts of property to the lower of cost or inflation-adjusted cost, and deny any deduction for capital appreciation in such gift property. A third proposal would eliminate the present provision for an above-the-line deduction for nonitemizers. All three of these proposals, taken together, would seriously erode the present levels of charitable giving in general and support of higher education in particular.

I would hope that the members of this Task Force will conclude that private support of research and of research infrastructure at universities, although small in relation to support by government in recent years, is a necessary, desirable, and vital activity, to be encouraged to the maximum reasonable extent. And should any of the above tax proposals become part of a tax simplification bill, I would hope that the members of this Task Force will oppose those proposals as contrary to the public interest.

This concludes my prepared statement. If there are any questions or needs for amplification of any of the above facts, I will be happy to try to provide the answers.

Table 1. Estimated Voluntary Support, by Source and Purpose (millions)

	1978-79	1982-83	1983-84	Percent change, 1983-84		
				v.1982-83	v.1978-79	v.1978-79 adj. for HEPI
TOTAL VOLUNTARY SUPPORT	$3,230	$5,160	$5,600	+ 8.5	+73.4	+15.6
Sources:						
Alumni	$ 785	$1,237	$1,305	+ 5.4	+66.2	+10.8
Nonalumni individuals	736	1,190	1,316	+10.6	+78.8	+19.2
Foundations	701	1,018	1,081	+ 6.2	+54.2	+ 2.8
Business Corporations	556	1,112	1,271	+14.3	+128.6	+52.7
Religious Organizations	161	206	190	- 7.8	+18.0	-21.6
Other	291	397	437	+10.1	+50.2	-
Purposes:						
Current Operations	$2,010	$3,125	$3,405	+ 9.0	+69.4	+12.8
Capital Purposes	1,220	2,035	2,195	+ 7.9	+79.9	+20.1
Price Indices (1967-100):						
Consumer (CPI)	206.4	293.8	304.8	+ 3.7	+47.7	
Higher Education (HEPI)	216.9	308.8	325.4	+ 5.4	+50.0	

Table 2. Voluntary Support for Research Purposes, by Donor Groups (millions)

	1972-73			1982-83		
	Amount	%	Percent of total support	Amount	%	Percent of total support
Alumni	$ 13.3	5.8	3.2	$ 24.8	3.9	2.4
Nonalumni Individuals	37.6	16.3	8.0	77.2	12.2	7.7
Foundations	89.0	38.6	21.7	207.4	32.7	24.1
Business Corporations	53.9	23.4	21.6	232.0	36.6	24.6
Religious Organizations	.1	-	.1	.4	-	.3
Other	36.9	16.0	29.3	92.9	14.6	27.7
	$230.8	100.0	13.2	$634.7	100.0	14.5

Table 3. Total Voluntary Support, Research Support, and Support for Physical Plant, by Purpose (Current Operations and Capital Purposes), 1982-83 (millions)

	Total Voluntary Support			Research Support			Support for Physical Plant		
	Total	Cur.	Cap.	Total	Cur.	Cap.	Total	Cur.	Cap.
Alumni	$1,046.9	$ 503.8	$ 543.1	$ 24.8	$ 18.0	$ 6.8	$132.5	$ 7.8	$124.7
Nonalumni Inds.	1,007.2	450.5	556.7	77.2	48.6	28.6	153.3	11.3	142.0
Foundations	862.1	497.2	364.9	207.4	198.2	9.2	177.9	14.3	163.6
Corportions	941.6	662.4	279.2	232.0	222.7	9.3	167.0	16.0	151.0
Religious Orgns.	174.4	150.2	24.2	.4	.1	.3	16.1	2.6	13.5
Other	335.9	260.3	75.6	92.9	90.1	2.8	22.6	3.4	19.2
Total	$4,368.1	$2,524.4	$1,843.7	$643.7	$577.7	$ 57.0	$669.4	$ 55.4	$614.0

Table 4. Estimated Voluntary Support and Support of Research, 1954-55 to 1983-84

	Total Voluntary Support	Support of Research	%
1954-55	$ 475	$ 60	12.5
1956-57	840	85	9.9
1958-59	760	105	14.0
1960-61	900	125	14.1
1962-63	1,050	140	13.4
1964-65	1,400	155	11.2
1965-66	1,440	205	14.4
1966-67	1,480	185	12.4
1967-68	1,600	200	12.5
1968-69	1,800	225	12.5
1969-70	1,780	215	12.1
1970-71	1,860	245	13.3
1971-72	2,020	260	12.8
1972-73	2,240	290	13.0
1973-74	2,240	290	13.0
1974-75	2,160	325	15.0
1975-76	2,410	355	14.7
1976-77	2,670	400	14.9
1977-78	3,040	475	15.7
1978-79	3,230	505	15.7
1979-80	3,800	575	15.1
1980-81	4,230	630	14.9
1981-82	4,860	675	13.9
1982-83	5,160	750	14.5
1983-84	5,600	840	15.0 (est.)

Table 5. Corporate Support of Colleges and Universities and Corporate Support of Research, by Type of Institution, 1982-83 (millions)

	Total Corporate Support	Corporate Research Support	%
Private Universities (73)	$ 334.1	$ 74.3	22.2
Private Men's Colleges (9)	1.5	-	-
Private Women's Colleges (77)	13.4	.2	-
Private Coeducational Colleges (495)	127.9	1.9	1.5
Private Professional & Specialized Insts. (90)	27.9	6.2	22.2
Total Private Four-Year Institutions (744)	$ 504.8	$ 82.7	16.3
Total Public Four-Year Institutions (267)	428.6	149.3	34.8
Total Four-Year Institutions (1,011)	$ 933.4	$ 232.0	24.8
Two-Year Institutions (126)	8.2	-	-
Grand Total, All Institutions (1137)	$ 941.6	$ 232.0	24.6

Note: Numbers in parentheses are numbers of participating institutions.

CFAE Council for Financial Aid
to Education, Inc.
680 Fifth Avenue, New York, New York 10019

CORPORATE GIFTS OF COMPANY PRODUCTS AND OTHER PROPERTY TO EDUCATION

Introduction

Corporate interest in donations of company products to colleges and universities grew sharply after the passage of the Economic Recovery Tax Act (ERTA) in August 1981. ERTA provided for enhanced tax deductions for gifts from inventory of products to be used in research or research training in the physical and biological sciences. CFAE started to collect data in 1982 about the total amounts of these gifts and of gifts of other types of property to education in its two annual surveys—Voluntary Support of Education and Corporate Support of Education. In the 1983 edition of the latter, 25 corporations reported donations of $47.5 million in company products to education. But no details existed about the nature of these gifts and company policies concerning them. Hence, a special survey was indicated.

In the fall of 1984, "product-property-gift" questionnaires were sent to 1,663 corporate contributions officers to solicit these additional details about gifts to education only. A total of 298 companies responded; 102 made gifts of company products, other property or both. An additional 7 had no formal programs but were beginning to track such contributions, which were usually made by divisions or subsidiaries. The remaining 189 did not make such gifts.

Survey Results

A breakdown of the responses by type of program and by industry sector follows:

Type of Program	Industry			Total
	Manufacturing	Nonmanufacturing	Unknown	
Company products only	19	2		21
Both products and other property	30	3		33
Other property only	15	30	3	48
TOTAL	64	35	3	102

Despite the fact that all of these companies indicated the existence of programs for making product or property gifts, not all of them made such gifts in any given year or even every year, nor could all of them put a value on such gifts. Some companies have not kept track of such gifts in the past. Some gifts were equipment that had already been fully depreciated and had no book value. Some companies did not answer all questions. Although the size of the sample is too small to permit generalization to the total corporate community, the data reported are sufficient to provide a valuable insight into the amount and nature of these gifts. The respondents also represent the major company product donors known to CFAE.

Gifts of Company Products

Nineteen companies in 8 manufacturing industries made donations of company products only. An additional 30 manufacturers in those 8 and two other industry groups gave both company products and other property. Two companies in a service industry gave company products, one through a manufacturing subsidiary. Three companies in three additional nonmanufacturing industry groups reported the existence of programs for making both types of gifts, although only one reported making such gifts during the period covered by the survey (1983 and 1984).

The value of product gifts, where known and reported, was as follows:

Gifts of Company Products

Industry	1983	1984
Manufacturing:		
Electrical machinery (21)	$61,729,490 (19)	$95,281,540 (14)
Chemicals & drugs (6)	13,910,196 (3)	167,917 (3)
Food, beverage & tobacco (4)	32,939 (3)	36,420 (3)
Machinery (4)	480,000 (3)	311,700 (3)
Fabricated metals (3)	32,800 (3)	252,000 (3)
Primary metals (3)	3,818 (1)	1,000 (1)
Paper & lumber (3)	1,500 (1)	11,800 (1)
Printing & publishing (2)	41,485 (2)	33,809 (2)
Petroleum & gas (2)	12,500 (2)	13,500 (2)
Transportation equipment (1)	25,000 (1)	---
Subtotal - Manufacturing (49)	$76,269,728 (38)	$96,109,286 (32)
Nonmanufacturing:		
Transportation (2)	$ 40,403 (2)	$ 45,000 (1)
All others (3)	300 (1)	500 (1)
Subtotal - Nonmanufacturing (5)	$ 40,703 (3)	$ 45,500 (2)
GRAND TOTAL (54)	$76,310,431 (41)	$96,155,186 (34)

(Numbers in parentheses show the number of companies reporting.)

As can be seen in the table, the electrical industry dominated this type of giving. Of the 19 electrical machinery companies donating their products in 1983, 7 (or 36.8 percent) said they gave only to colleges, while 12 (or 63.2 percent) gave to both colleges and precollege institutions. In 1984, 6 (42.9 percent) gave to colleges only and 8 (57.1 percent) gave to both educational levels. None gave only to precollege institutions in either year.

Of the remaining 33, 13 (44.8 percent) gave to colleges only, 6 (20.7 percent) to precollege institutions only and 34 (34.5 percent) to both. Four did not indicate an educational level.

There was considerable variation in valuation practices. Of the 54 companies reporting donations of company products, 22, or just under 41 percent, used the sales price, list price or fair market value to notify recipients of the value of the gift. Another 18, or 33.3 percent, employed a lesser figure, including the discounted price, the book value, cost, or half the difference between cost and resale price. These latter mechanisms may apply to the "other property" gifts that some of these companies made, because the questionnaire did not differentiate between the two types of gift when asking for methods of notifying donees of gift values. Just over one quarter (13, or 25.9 percent) either did not answer or did not notify recipients of the value of the gift. One company, for example, explained that the donation was already fully depreciated. Obviously, this comment applied to gifts of other property.

Forty of the manufacturers and three of the nonmanufacturers donating only company products took them as a tax deduction in 1983; the numbers dropped to 37 and 3, respectively, in 1984. Some of the respondents made no product gifts in 1983; others made none in 1984. The sample was different each year.

Gifts from 11 companies were eligible for the enhanced deduction under Section 170(e)(3) of the Internal Revenue Code for "care of the ill, the needy, or infants." Gifts from 21 companies were eligible for the enhanced deduction under Section 170(e)(4) for research or research training, as provided in ERTA. Although 15 of the companies indicated that they had written policies and forms for certification by the recipient about the use of the donations, only four were able to provide copies.

Gifts of Other Property

Other property donations were almost entirely used or surplus items. They are often unplanned, and data about their value tend to be very lumpy. Most frequently they were used furniture or office equipment, but also included used audiovisual or computer equipment, used vehicles or paper and office supplies. Occasionally, companies gave real estate and art works, usually on a one-time basis, and some of them at times provided construction materials or *pro bono* services, with no tax deduction being taken on the latter.

Of the 45 manufacturing companies that donated other property to educational institutions, the 30 that gave both products and property represented 10 industries; the 15 that confined their gifts to other property were in only 7 of these industries. The 30 nonmanufacturers that gave other property were in 7 industry groups, with the three that also gave company products in three of those groupings.

The breakdown of corporate gifts of other property by industry groupings is as follows:

Corporate Gifts of Other Physical Property

Industry	1983		1984	
Manufacturing:				
Electrical machinery (14)	$ 1,876,742	(6)	$ 2,576,000	(5)
Chemicals & drugs (9)	8,699,218	(4)	276,917	(3)
Petroleum & gas (6)	1,760,753	(3)	71,700	(3)
All others (16)	1,524,078	(5)	188,662	(6)
Subtotal - Manufacturing (45)	$13,860,791	(18)	$ 3,113,279	(17)
Nonmanufacturing:				
Utilities (9)	$ 302,672	(7)	$ 18,116	(5)
Insurance (7)	97,500	(4)	9,200	(3)
Banking (6)	51,500	(2)	---	
Telecommunications (5)	2,142,616	(4)	1,342,347	(4)
Engineering & Construction (2)	15,000	(2)	10,000	(2)
All others (4)	20,000	(1)	---	
Subtotal - Nonmanufacturing(33)	$ 2,629,288	(20)	$ 1,379,663	(14)
Unknown (anonymous replies) (3)	$ 623,500	(3)	$ 117,500	(2)
GRAND TOTAL (81)	$17,113,579	(41)	$ 4,610,442	(33)

(Numbers in parentheses show the number of companies reporting.)

Only 74 of the respondents indicated the educational level to which they made property gifts. Almost half (36, or 48.7 percent) gave to both colleges and universities and precollege institutions; 30, or 40.5 percent, gave to colleges only and 8, or 10.8 percent, to schools only.

Of the 48 companies that only gave property, 28 notified recipients of the value of their gifts. Fifteen, or 31.2 percent, used the list price or fair market value; 13, or 27.1 percent, applied a variant, such as the net depreciated value, the salvage value or an appraised value. The rest (20, or 41.7 percent) either did not answer or had already depreciated the property and therefore took no tax deduction on it. Slightly over half (26) of the companies took a tax deduction for their property gifts in 1983; exactly half did so in 1984.

Where do Proposals Originate?

Most requests for company products came from recipients, but an almost equal number of offers of gifts originated with the companies. Most of the companies responded to requests as well as made their own offers. Three respondents also received proposals from employees outside the contributions function for gifts to organizations they worked with.

Requests for gifts of "other" property originated equally from donee requests and from within the companies. Again, most companies received proposals from both sources. Two also received proposals from employees who had worked with the recipient organization.

Discounted Pricing

Fourteen of the companies donating only their own manufactured products also sold their products to educational institutions at discounted prices. These companies were in three industries: electrical machinery, printing and publishing and petroleum and gas. Most of them indicated that they gave standard, industry-wide discounts. A few, however, reported that discounting was done only by certain divisions or subsidiaries and that there was no company-wide policy. A few others were in the process of setting up a company policy. The remainder of the respondents either reported that their company had no such policy or did not answer the question.

CFAE Research
1/30/85

Mr. FUQUA. Now we will hear from Dr. Frank Sprow, vice president of Exxon Research & Engineering Co.

[A biographical sketch of Dr. Sprow follows:]

DR. FRANK B. SPROW

Dr. Sprow received his Bachelor of Science (1962) and Master of Science (1963) degrees in Chemical Engineering from MIT and his Ph.D. in Chemical Engineering (1965) from the University of California at Berkeley.

Dr. Sprow assumed his current position in December 1982 as Vice President, Technology Support for Exxon Research and Engineering Company, Clinton, New Jersey. Technology Support is responsible for managing business and technical support to ER&E's R&D and engineering activities. This includes financial, legal, analytical, computing, and other areas. Construction and planning for ER&E's new facilities are also included.

He began his career with Exxon at Baytown, Texas, in 1965 and worked in various engineering and supervisory positions there. In May 1971, Dr. Sprow joined Exxon U.S.A.'s Supply Department in Houston, and later became Head of Commerce-Raw Materials, responsible for negotiations for purchase and sale of Exxon's U.S. crude oil supplies. He then became Technical Manager of Exxon U.S.A.'s Bayway, New Jersey Refinery in August 1975 and was named Operations Manager in August 1977. Dr. Sprow joined Exxon Research and Engineering in March 1979 and was General Manager of Petroleum R&D Programs. In January 1980, he was promoted to Vice President, Synthetic Fuels Research, where he was responsible for development and management of Exxon's research efforts on the conversion of coal and shale to liquid and gaseous products.

Dr. Sprow is a member of the AIChE and the Society of Automotive Engineers. He is active in Exxon's university relationships programs and has served on various college advisory boards.

STATEMENT OF DR. FRANK B. SPROW, VICE PRESIDENT, EXXON RESEARCH & ENGINEERING CO., ANNANDALE, NJ

Dr. SPROW. Thank you, Mr. Chairman.

It is a pleasure to have the opportunity to offer an industry perspective regarding the research infrastructure at the university.

I am quite concerned about the condition of our university research facilities. Frequently, when I visit a university lab, I see obsolete instruments, crowded and marginally safe facilities, and the move to shared computing and electronically-linked research apparatus has passed many schools by.

At the same time the health of the university research system is critical to industry. We need trained graduates in our own laboratories and fundamental work is carried out on the universities which is too speculative for profit-making firms to engage in.

This problem needs more than money as a cure. If we continue with current methods of funding university research, not enough money could be printed to really solve the infrastructure problem on a continuing basis, especially if the United States wants to retain its technological edge.

As severe as this problem is, in my view it could well be much worse but for the 1981 Tax Act which provides an incentive for corporate donations of research and development equipment to universities. The fruits of this program are obvious, most particularly in the electronics and computing disciplines. The coming consideration of tax reform proposals should certainly include this discussion of this important area.

Let me back up and say that in my experience an effective research and development program has five requirements:

First, creative people working independently and in teams.

Next, state-of-the-art facilities and tools.

Next, establishment of realistic research objectives, including how the work will be used if it succeeds.

Next, sharing of resources to save money.

Finally, but very importantly, stewarding the results of the research to insure that we have learned from the experience, positive or negative. Did we get what we paid for? If we did, fine. If not, why not?

The current system of individual grants to university researchers has been successful in the first of these, attracting creative people, but contributes relatively little to the other four. An alternate approach that would lend itself to greater utilization of business principles for managing our research resources would be the adoption of supplemental institutional grants to encourage the establishment of a centralized facility. Such centers would be collaboratively managed by the institutions using them. As envisioned here, they would facilitate the acquisition, maintenance, and sharing of instrumentation. Flexible guidelines could enable the aggregation of funds for the purchase of expensive instruments.

Second, a reasonable level and continuity of funding could allow a long-term commitment to provide adequate maintenance support and operating personnel.

Third, the scale of the programs would make it possible to provide shared instrumentation and management in a cost-effective manner.

The principal motivation behind establishing and funding centralized research facilities is an attempt to solve the dilemma created by the combined increases in the need for and the cost of modern research facilities.

At some cost threshhold, it is clear that centralized research facilities are necessary, because the infrastructure required to support research is simply too expensive to continue to exist under the purview of the individual researcher, a single department, a single university, or a single company.

The concept of shared research facilities is already established in the field of physics where instrumentation at very high cost is required; for example, synchrotron light sources.

When instrumentation and facilities of such high capital and operating costs are involved, there is no alternative to shared facilities. There are several successful university, industry, and Government cooperative arrangements in operations today. Under the direction of Stanford University, an accelerator was constructed with Federal funds. Usage of this instrument, while managed by Stanford, is allocated on a proposal basis to industry, Government, and other universities.

Industry has contributed significant resources to improve the capabilities of this facility. For example, in partnership with the Lawrence Berkeley Laboratory and Stanford, we at Exxon have expanded the facility to include the world's most powerful x-ray source which is used for materials science research. A similar collaboration which we are involved in exists at Brookhaven Laboratory on Long Island where the National Synchrotron Light Source is managed by an advisory committee of representatives from several universities.

The participating research team concept enables industry as well as university and Government labs to contribute funds and expertise to enhance and upgrade the instrumentation in return for priority use.

Collaboration between universities and industry in centers or through other vehicles provides an opportunity to take unique advantage of the different characteristics of each, the universities on the one side, industry on the other.

Universities often have difficulty upgrading their facilities and instrumentation. At the same time, labor costs are low at universities due to the involvement of graduate students in the research program.

In industry, just the converse is true. Investment in equipment presents no unusual hurdles. If it is justified, it is purchased. At the same time, labor costs are quite high in industry due to extensive overhead associated with recruiting, training, and other typically corporate costs. This suggests collaborations in such centers where at the margin equipment is supplied by industry and staffing from universities.

I also believe it is time that universities and the Government give serious consideration to some of the management procedures and techniques which have been used by industry to increase efficiency and output. The principles have been around for a long time: justification, objectives set, stewardship. These principles are just as applicable to individual university administrations as they are to shared instrumentation facilities.

The establishment of a formal justification procedure going beyond initial procurement would help insure cost efficiency and improve return on investment not only for the procurement of equipment, but also its maintenance, upgrading, and eventual replacement based on expected obsolescence rates.

Proposals to acquire equipment should be required to address questions of continuing maintenance, training needs, safety of operating personnel, planned use, availability of existing instruments which might do the job, and included in that analysis of alternatives to the proposal.

Setting objectives for what we expect to achieve would provide benchmarks for measuring and controlling progress. Just what is it that we need to measure, with what accuracy, how rapidly?

In industry, such objectives are crucial to good long-range planning, and the efficient rebuilding of our research infrastructure requires just such a long-range view.

The establishment of a stewardship mechanism can help insure maximum scientific results with the resources expended. In the absence of a direct economic and competitive focus, there is a need for a mechanism to insure accountability. In industry we hold researchers accountable for their investment decisions as well as the quality and productivity of their research work. While we dare not breathe excessive conservatism into a research organization, an intelligently applied, continuing appraisal process is needed so that we can allocate scarce funds to the most productive laboratories and the most effective workers.

There is also a great opportunity for the Federal Government to leverage its funds through collaborations with State governments who have also begun to recognize the importance of a healthy research infrastructure to their economic well being.

In my State, New Jersey, the Governor established a special commission to examine ways of upgrading the State's research infrastructure. The commission recommended the passage of a bond issue to create four advanced technology research centers at key New Jersey universities. The electorate approved the bond issue in the November 1984 general election.

In addition to conducting research on new techniques, these centers will share information with other academic institutions, government, industry, and the public.

These are suggestions meant to stimulate discussion on solutions to this critical problem. I have expanded on them in my submitted testimony.

Research is becoming so capital-intensive that strong management procedures must be used to insure that our country's technological investments yield maximum return. At the same time we must recognize that a purely business approach will not fit. Universities are and should be different.

I do know that in encouraging our researchers and managers to work with universities on this issue, industry has demonstrated a willingness to help and that this help is needed.

Thank you.

[The prepared statement of Dr. Sprow follows:]

STATEMENT

before the

TASK FORCE ON SCIENCE POLICY

COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

by

Dr. Frank B. Sprow
Vice President

EXXON RESEARCH AND ENGINEERING COMPANY

May 22, 1985

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE:

MY NAME IS FRANK SPROW, AND I AM VICE PRESIDENT, TECHNOLOGY SUPPORT, EXXON RESEARCH AND ENGINEERING COMPANY. MY RESPONSIBILITIES INCLUDE PROVIDING BUSINESS AND TECHNICAL SUPPORT TO THE COMPANY'S RESEARCH AND DEVELOPMENT ACTIVITIES. I ALSO SERVE AS A MEMBER OF THE GOVERNMENT RELATIONS COMMITTEE OF THE COUNCIL FOR CHEMICAL RESEARCH, AND THE COMMITTEE ON SCIENCE, ENGINEERING AND PUBLIC POLICY (COSEPP) OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. BOTH OF THESE GROUPS ARE VERY INTERESTED IN THE INSTRUMENTATION AND INFRASTRUCTURE PROBLEMS FACING UNIVERSITY RESEARCHERS, AS WELL AS OTHER MATTERS BEING CONSIDERED BY THE COMMITTEE.

I WELCOME THE OPPORTUNITY TO OFFER AN INDUSTRY PERSPECTIVE TO THE MANAGEMENT OF OUR RESEARCH INFRASTRUCTURE. THE HEALTH OF UNIVERSITY RESEARCH AND TEACHING IS CRITICAL TO THE U.S. INDUSTRIAL COMMUNITY FOR TWO PRIMARY REASONS. FIRST, THE UNIVERSITY SYSTEM PROVIDES INDUSTRY WITH A CONTINUING STREAM OF HIGHLY TRAINED TECHNICAL

PERSONNEL. SECOND, IT PERMITS THE EXPLORATION OF IDEAS THAT PROMISE POTENTIALLY LARGE PAYOFFS FOR THE NATION, BUT THAT ARE AS YET TOO SPECULATIVE TO JUSTIFY SUBSTANTIAL INVESTMENT BY A COMPANY SEEKING TO MAKE A PROFIT. AMERICA'S ABILITY TO COMPETE INTERNATIONALLY IS FACING UNPRECEDENTED CHALLENGE FROM ABROAD. MAINTAINING THE HEALTH OF OUR RESEARCH EQUIPMENT AND FACILITIES IS ESPECIALLY CRITICAL TO THIS COMPETITION. MOST INDUSTRIAL RESEARCHERS AND ACADEMICS AGREE THAT THE RESEARCH INFRASTRUCTURE IS CURRENTLY IN A STATE OF SERIOUS DECLINE.

THE FEDERAL GOVERNMENT'S SUPPORT FOR RESEARCH AND TEACHING LABORATORY EQUIPMENT AND FACILITIES GREW RAPIDLY THROUGH THE 50'S AND 60'S, RESPONDING TO A PENT-UP DEMAND FOR HIGHER EDUCATION, INCREASED ENROLLMENTS, AND AN EXPLODING BODY OF SCIENTIFIC AND TECHNOLOGICAL KNOWLEDGE. THE NATIONAL SCIENCE FOUNDATION (NSF), THE DEPARTMENT OF DEFENSE (DOD), AND NATIONAL INSTITUTES OF HEALTH (NIH) ASSUMED THE PRINCIPAL RESPONSIBILITY FOR ALLOCATING FEDERAL FUNDS. THE PRIMARY MECHANISM USED WAS A SYSTEM OF GRANTS-IN-AID TO COMPETITIVELY PEER-REVIEWED PROJECTS. THIS RESEARCH SYSTEM WAS SUCCESSFUL IN ESTABLISHING THE U.S. AS THE WORLD LEADER IN BASIC SCIENCE. WE HAVE

ENCOURAGED INNOVATIVE NEW TECHNOLOGIES AND BUILT A RESEARCH BASE THAT REMAINS THE STRONGEST AND MOST PRODUCTIVE IN THE WORLD.

HOWEVER, SINCE 1968 FEDERAL FUNDING FOR MAINTAINING OUR RESEARCH INFRASTRUCTURE HAS REMAINED ESSENTIALLY FLAT IN REAL DOLLARS. THE GOVERNMENT NOW PROVIDES ABOUT ONE-SIXTH OF THE ESTIMATED $2.0 BILLION DOLLARS SPENT PER YEAR BY UNIVERSITIES FOR EQUIPMENT AND FACILITIES, AS COMPARED TO ONE-THIRD IN 1968. TO MY KNOWLEDGE, THERE IS NOW NO PLANNED EFFORT BY NSF OR ANY MISSION AGENCY SPECIFICALLY DESIGNED TO HELP MAINTAIN AND REBUILD UNIVERSITY RESEARCH FACILITIES. WE HAVE INSTEAD RELIED ON THE RESEARCH FUNDING "SYSTEM" TO SEE TO THE STRENGTH OF OUR RESEARCH INFRASTRUCTURE. THERE HAS BEEN NO EXPLICIT DEFINITION OF THE RESPONSIBILITY OF THE FEDERAL GOVERNMENT. AS A CONSEQUENCE, SEVERAL SCHOOLS HAVE LOBBIED CONGRESS DIRECTLY FOR SUPPORT, BYPASSING THE TRADITIONAL SCIENTIFIC PEER-REVIEW SYSTEM. THESE TACTICS HAVE RESULTED IN FUNDS FOR FACILITIES BEING INSERTED IN CONGRESSIONAL APPROPRIATIONS BILLS. HOWEVER DISCONCERTING THIS MAY BE TO THE RESEARCH COMMUNITY, IT HAS BEEN DRIVEN BY REAL NEEDS AND THE INADEQUACY OF EXISTING MECHANISMS TO MEET THEM.

ONE COULD ARGUE AT LENGTH OVER THE SIZE OF THE PROBLEM. FOR EXAMPLE, THE DEPARTMENT OF DEFENSE (DOD) HAS ESTIMATED THAT $1.5 to $2.0 BILLION WOULD BE REQUIRED TO ELEVATE QUALIFIED ACADEMIC LABORATORIES TO "WORLD-CLASS" STATUS IN INSTRUMENTATION. WHETHER THIS IS SOMEWHAT EXAGGERATED, UNDERESTIMATED, OR RIGHT ON THE MARK DOESN'T REALLY MATTER. THE PROBLEM IS A MAJOR ONE.

ANOTHER INDICATION OF THE EXTENT OF THE NEED IS TO GAUGE DEMAND. FOR EXAMPLE, CONSIDER THE RESPONSE TO THE RECENT NSF INITIATIVE TO CREATE SUPERCOMPUTING CENTERS AT UNIVERSITIES. THE INITIAL $20 MILLION PROGRAM DREW $1 BILLION IN PROPOSALS. A FURTHER INDICATION OF NEED COMES FROM THE RESPONSE TO A PROGRAM INITIATED BY DOD. IT PROVIDES $30 MILLION ANNUALLY FOR SUPPORT OF INSTRUMENTATION IN ACADEMIC SCIENCE AND ENGINEERING. THIS PROGRAM HAS DRAWN PROPOSALS TOTALLING NEARLY $650 MILLION.

AS SEVERE AS THE PROBLEM IS, IN MY VIEW IT COULD WELL BE MUCH WORSE BUT FOR THE 1981 TAX ACT WHICH PROVIDES AN INCENTIVE FOR CORPORATE DONATIONS OF RESEARCH AND DEVELOPMENT EQUIPMENT TO UNIVERSITIES. THE FRUITS OF THIS PROGRAM ARE OBVIOUS, MOST PARTICULARLY IN THE ELECTRONICS

AND COMPUTING DISCIPLINES. THE COMING CONSIDERATION OF TAX REFORM PROPOSALS SHOULD INCLUDE DISCUSSION OF THIS IMPORTANT AREA.

AS DIFFICULT AS THE SITUATION IS FOR INSTRUMENTATION, REBUILDING CAMPUS LABORATORY FACILITIES IS PERHAPS EVEN MORE CHALLENGING. MANY OF US IN INDUSTRY ARE SHOCKED WHEN WE EXPERIENCE THE CURRENT STATE OF MANY UNIVERSITY LABORATORIES. THE NEEDS FOR MODERNIZED FACILITIES ARISE FROM CHANGES IN PROGRAMS AND TECHNOLOGIES, PHYSICAL DETERIORATION, AND COMPLIANCE WITH GOVERNMENTAL SAFETY AND ENVIRONMENTAL REGULATIONS. A RECENT NSF SURVEY OF PLANNED CAPITAL EXPENDITURES AT 25 MAJOR RESEARCH UNIVERSITIES--EXTRAPOLATED TO ALL RESEARCH UNIVERSITIES--ESTIMATES THAT $1.3 BILLION PER YEAR WOULD BE NEEDED TO MEET FACILITY NEEDS. THE ESTIMATE OF FUNDS REQUIRED IS NOT SURPRISING. MY OWN COMPANY RECENTLY COMPLETED CONSTRUCTION OF A NEW LABORATORY IN CLINTON, NEW JERSEY, TO PROVIDE STATE-OF-THE-ART FACILITIES FOR SEVERAL HUNDRED SCIENTISTS. THE COST OF THIS FACILITY WAS OVER $200 MILLION, CORRESPONDING TO OVER $300 PER SQUARE FOOT OF LAB SPACE. IN ADDITION TO MAKING THE FACILITY STATE-OF-THE-ART, SAFETY AND ENVIRONMENTAL COMPLIANCE WERE OF CONCERN, AND ARE INCREASINGLY COSTLY.

SOLVING THE INFRASTRUCTURE PROBLEM WILL NOT BE EASY. SINCE THE INSTRUMENTATION AND FACILITY HORIZON IS CONSTANTLY MOVING, ANY SOLUTIONS DEVISED WILL HAVE TO BE SUSTAINED ONES, NOT ONE-SHOT EFFORTS. THE POLICIES AND INSTITUTIONS THAT WORKED IN THE PAST WILL LIKELY NOT BE APPROPRIATE FOR THE FUTURE BECAUSE OF RAPID CHANGES IN TECHNOLOGY, AND INTENSE COMPETITION FOR SCARCE FEDERAL RESOURCES.

THIS COMMITTEE HAS RECEIVED A GREAT DEAL OF TESTIMONY RECOMMENDING APPROACHES TO PROVIDING INCREASED SUPPORT FOR THE MAJOR PRE-REQUISITES--TRAINED PERSONNEL, STATE-OF-THE-ART EQUIPMENT, AND MODERN FACILITIES--NECESSARY FOR SUCCESSFUL RESEARCH AND DEVELOPMENT. WHAT HAS OFTEN BEEN OVERLOOKED IN THE DISCUSSION HAS BEEN THE NEED FOR BETTER SYSTEMS FOR MANAGING, OPERATING, SHARING, AND STEWARDING RESEARCH RESOURCES. MANAGEMENT ISSUES HAVE LARGELY BEEN LEFT UNADDRESSED, DUE PERHAPS TO OUR HIGHLY DECENTRALIZED SYSTEM OF UNIVERSITY RESEARCH. IT IS TIME THAT WE ADDRESS THEM BECAUSE THERE ARE ABUNDANT OPPORTUNITIES TO BOTH INCREASE RESEARCH OUTPUT AND EFFICIENCY.

THE FEDERAL GOVERNMENT CLEARLY HAS TO ASSUME SOME DEGREE OF DIRECT RESPONSIBILITY, BUT IT CANNOT SOLVE

THE PROBLEM BY ITSELF, PARTICULARLY IN AN ERA OF LIMITED RESOURCES. THE PROBLEM CAN BE EFFECTIVELY ADDRESSED BY AN AMALGAM OF THE BEST MANAGEMENT TECHNIQUES OF UNIVERSITIES, INDUSTRY, AND GOVERNMENT.

OUR RESEARCH INFRASTRUCTURE CAN BENEFIT SUBSTANTIALLY FROM THE APPLICATION OF MANAGEMENT PROCEDURES AND TECHNIQUES DEVELOPED IN THE INDUSTRIAL RESEARCH SECTOR. HOWEVER, THE USE OF THESE PROCEDURES WILL REQUIRE CONSIDERATION OF ALTERNATE MECHANISMS FOR ALLOCATING FEDERAL RESEARCH FUNDS TO UNIVERSITIES AND INDIVIDUAL INVESTIGATORS. AT THE SAME TIME, WE SHOULD NOT OVER-CENTRALIZE AND DESTROY THE AUTONOMY AND DIVERSITY NEEDED FOR GOOD RESEARCH.

THE CURRENT PROJECT GRANT SYSTEM, WHICH HAS BEEN SUCCESSFUL IN DIRECTING FEDERAL FUNDS INTO HIGH-QUALITY RESEARCH, HAS IN SEVERAL WAYS ADVERSELY AFFECTED THE MAINTENANCE OF OUR RESEARCH INFRASTRUCTURE, PARTICULARLY IN THE AREA OF INSTRUMENTATION. THE INTENSE COMPETITION FOR THE LIMITED FUNDS AVAILABLE HAS AFFECTED THE FUNDING ALLOCATION DECISIONS OF PEER REVIEW COMMITTEES, OFTEN LEADING TO SPECIFIC DENIAL OF FUNDS REQUESTED FOR INSTRUMENTATION.

IT HAS DISCOURAGED INVESTIGATORS FROM APPLYING FOR NEEDED INSTRUMENTATION OR DETERRED THEM FROM UNDERTAKING RESEARCH REQUIRING IT. IT HAS LED SOME INVESTIGATORS TO DEFER ACQUISITION OF INSTRUMENTATION IN ORDER TO USE LIMITED FUNDS TO PRESERVE SCIENTIFIC AND SUPPORT STAFF.

AN ALTERNATE APPROACH THAT WOULD LEND ITSELF TO GREATER UTILIZATION OF BUSINESS PRINCIPLES FOR MANAGING OUR RESEARCH RESOURCES WOULD BE THE CREATION OF A NEW SUPPLEMENTAL INSTITUTIONAL EQUIPMENT GRANT TO ENCOURAGE THE ESTABLISHMENT OF CENTRALIZED FACILITIES. SUCH CENTERS WOULD BE COLLABORATIVELY MANAGED BY THE INSTITUTIONS USING THEM. AS ENVISIONED HERE, THEY WOULD FACILITATE THE ACQUISITION, MAINTENANCE, AND SHARING OF INSTRUMENTATION. FLEXIBLE GUIDELINES COULD ENABLE THE AGGREGATION OF FUNDS FOR THE PURCHASE OF EXPENSIVE INSTRUMENTS. SECOND, A REASONABLE LEVEL AND CONTINUITY OF FUNDING COULD ALLOW A LONG-TERM COMMITMENT TO PROVIDE ADEQUATE MAINTENANCE SUPPORT AND OPERATING PERSONNEL. AND THIRD, THE SCALE OF PROGRAMS WOULD MAKE IT POSSIBLE TO PROVIDE SHARED INSTRUMENTATION AND MANAGEMENT IN A COST-EFFECTIVE MANNER.

THE PRINCIPAL MOTIVATION BEHIND ESTABLISHING AND FUNDING CENTRALIZED RESEARCH FACILITIES IS AN ATTEMPT TO SOLVE THE DILEMMA CREATED BY THE COMBINED INCREASES IN THE NEED FOR AND COSTS OF MODERN RESEARCH FACILITIES. AT SOME COST THRESHOLD, IT IS CLEAR THAT CENTRALIZED RESEARCH FACILITIES ARE NECESSARY, BECAUSE THE INFRASTRUCTURE REQUIRED TO SUPPORT RESEARCH IS SIMPLY TOO EXPENSIVE TO CONTINUE TO EXIST UNDER THE PURVIEW OF THE INDIVIDUAL RESEARCHER, A SINGLE DEPARTMENT, A SINGLE UNIVERSITY OR COMPANY.

THE CONCEPT OF SHARED RESEARCH FACILITIES IS ALREADY ESTABLISHED IN THE FIELD OF PHYSICS WHERE INSTRUMENTATION OF VERY HIGH COST IS REQUIRED, SUCH AS SYNCHROTRON LIGHT SOURCES. WHEN INSTRUMENTATION AND FACILITIES OF SUCH HIGH CAPITAL AND OPERATING COST ARE INVOLVED, THERE IS NO ALTERNATIVE TO SHARED FACILITIES. THERE ARE SEVERAL SUCCESSFUL UNIVERSITY, INDUSTRY, AND GOVERNMENT CO-OPERATIVE ARRANGEMENTS IN OPERATION TODAY. UNDER THE DIRECTION OF STANFORD UNIVERSITY, AN ACCELERATOR WAS CONSTRUCTED WITH FEDERAL FUNDS (DOE). USAGE OF THIS INSTRUMENT, WHILE MANAGED BY STANFORD, IS ALLOCATED ON A PROPOSAL BASIS TO INDUSTRY, GOVERNMENT AND OTHER UNIVERSITIES. INDUSTRY HAS CONTRIBUTED SIGNIFICANT RESOURCES TO

IMPROVE THE CAPABILITIES OF THE FACILITY. FOR EXAMPLE, IN PARTNERSHIP WITH LAWRENCE BERKELEY LABORATORY AND STANFORD, WE IN EXXON HAVE EXPANDED THE FACILITY TO INCLUDE THE WORLD'S MOST POWERFUL X-RAY SOURCE (FOR MATERIALS SCIENCE). A SIMILAR COLLABORATION EXISTS AT BROOKHAVEN LABORATORY ON LONG ISLAND, WHERE THE NATIONAL SYNCHROTRON LIGHT SOURCE IS MANAGED BY AN ADVISORY COMMITTEE OF REPRESENTATIVES FROM SEVERAL UNIVERSITIES. THE PARTICIPATING RESEARCH TEAM CONCEPT ENABLES INDUSTRY, AS WELL AS UNIVERSITY AND GOVERNMENT LABS, TO CONTRIBUTE FUNDS AND EXPERTISE FOR ENHANCING AND UPGRADING THE INSTRUMENTATION IN RETURN FOR PRIORITY USE. OTHER CENTRALIZED FACILITIES USED BY MY COMPANY ARE THE INTENSE PULSED NEUTRON SOURCE AT THE ARGONNE NATIONAL LABORATORY IN CHICAGO, THE NATIONAL CENTER FOR SMALL ANGLE SCATTERING RESEARCH AT OAK RIDGE, TENN. AND THE NEUTRON SCATTERING RESEARCH FACILITY AT THE UNIVERSITY OF MISSOURI. PURCHASE OF SUCH SOPHISTICATED INSTRUMENTATION BY INDUSTRIAL LABORATORIES CANNOT BE COST JUSTIFIED. OUR EXPERIENCE HAS SHOWN THAT PARTICIPATION IN COOPERATIVE AGREEMENTS IS MORE COST EFFICIENT AND WE ALSO BENEFIT FROM CONTACT WITH THE COMMUNITY OF RESEARCHERS IN THESE CENTERS.

COLLABORATION BETWEEN UNIVERSITIES AND INDUSTRY IN CENTERS OR THROUGH OTHER VEHICLES PROVIDES AN OPPORTUNITY TO TAKE ADVANTAGE OF THE DIFFERENT CHARACTERISTICS OF EACH. UNIVERSITIES OFTEN HAVE DIFFICULTY UPGRADING FACILITIES AND INSTRUMENTATION FOR THE REASONS ALREADY OUTLINED. AT THE SAME TIME, LABOR COSTS ARE LOW DUE TO THE INVOLVEMENT OF GRADUATE STUDENTS IN THE RESEARCH PROGRAMS. IN INDUSTRY, THE CONVERSE IS TRUE. INVESTMENT IN EQUIPMENT PRESENTS NO UNUSUAL HURDLES--IF IT IS JUSTIFIED, IT IS PURCHASED. AT THE SAME TIME, LABOR COSTS ARE HIGH DUE TO EXTENSIVE OVERHEADS ASSOCIATED WITH RECRUITING, TRAINING, AND OTHER TYPICALLY "CORPORATE" COSTS. THIS SUGGESTS COLLABORATIONS WHERE -- AT THE MARGIN -- EQUIPMENT IS DISPROPORTIONATELY SUPPLIED BY INDUSTRY AND STAFFING FROM UNIVERSITIES.

STATE GOVERNMENTS HAVE ALSO BEGUN TO RECOGNIZE THE IMPORTANCE OF A HEALTHY RESEARCH INFRASTRUCTURE TO THEIR ECONOMIC WELL-BEING. IN MY STATE, NEW JERSEY, THE GOVERNOR ESTABLISHED A SPECIAL COMMISSION TO EXAMINE WAYS OF UPGRADING THE STATE'S RESEARCH INFRASTRUCTURE. THE COMMISSION RECOMMENDED THE PASSAGE OF A BOND ISSUE TO CREATE FOUR ADVANCED TECHNOLOGY RESEARCH CENTERS AT KEY

NEW JERSEY UNIVERSITIES. THE ELECTORATE APPROVED THE BOND ISSUE IN THE NOVEMBER 1984 GENERAL ELECTION. IN ADDITION TO CONDUCTING RESEARCH ON NEW TECHNIQUES, THESE CENTERS WILL SHARE INFORMATION WITH OTHER ACADEMIC INSTITUTIONS, GOVERNMENT, INDUSTRY, AND THE PUBLIC. THE KEY POINT HERE, AS REGARDS INFRASTRUCTURE, IS THAT THESE RESEARCH CENTERS ARE BEING ESTABLISHED IN AREAS WHERE THERE IS CLEAR ECONOMIC AND INDUSTRIAL NEED AND WHERE SOME RESIDENT CAPABILITY ALREADY EXISTS IN THE STATE. FURTHERMORE, IT IS REQUIRED THAT THE ACADEMIC INSTITUTION HOUSING THE CENTERS SHARE EQUIPMENT AND FACILITIES. ALL PARTICIPANTS WERE MADE AWARE THAT RESOURCES WERE NOT SUFFICIENT TO ALLOW FOR DUPLICATION. INDUSTRY IS BEING WELCOMED INTO THESE ACTIVITIES.

EVEN WITHIN THE EXISTING FRAMEWORK OF OUR NATIONAL LABORATORIES, THERE ARE OPPORTUNITIES FOR THE APPLICATION OF SOME BASIC MANAGEMENT PRACTICES. SEVERAL OF THESE PRACTICES WERE RECOMMENDED TO THE PRESIDENT AS A RESULT OF A YEAR-LONG REVIEW OF THE NATION'S FEDERAL LABORATORIES CONDUCTED BY THE WHITE HOUSE SCIENCE COUNCIL. I ENDORSE THE SUGGESTIONS OFFERED BY THE STUDY PANEL

CHAIRED BY DAVID PACKARD, AIMED AT ELIMINATING DEFICIENCIES THAT LIMIT BOTH THE QUALITY AND COST EFFECTIVENESS OF THE RESEARCH PERFORMED AT OUR FEDERAL LABORATORIES. TO IMPROVE MANAGEMENT, THE PANEL RECOMMENDED THE ESTABLISHMENT OF AN EXTERNAL OVERSIGHT COMMITTEE, INCLUDING UNIVERSITY AND INDUSTRY REPRESENTATIVES, TO EVALUATE PERFORMANCE AND RESULTS. SECOND, THE PANEL RECOMMENDED THAT LAB DIRECTORS BE HELD ACCOUNTABLE FOR THE QUALITY AND PRODUCTIVITY OF THEIR LABORATORIES. THE THIRD RECOMMENDATION FOR IMPROVING MANAGEMENT DEALT WITH REDUCING THE DEGREE OF DETAILED DIRECTION EXERCISED BY PARENT AGENCIES.

THERE IS AN URGENT NEED TO IMPROVE MANAGEMENT CAPABILITIES FOR DEVELOPING AND MAINTAINING OUR RESEARCH INFRASTRUCTURE. WITH THE ESTABLISHMENT OF NEW SHARED RESEARCH CENTERS AND THE FUNDING MECHANISMS TO SUPPORT THEM, THERE ARE SEVERAL ADDITIONAL APPROACHES THAT COULD BE CONSIDERED FOR MANAGING FEDERAL AND UNIVERSITY INSTRUMENTS AND FACILITIES. AT THE RISK OF SOUNDING LIKE A MANAGEMENT TEXTBOOK, THE PRINCIPLES HAVE BEEN AROUND FOR A LONG TIME: JUSTIFICATION, OBJECTIVE SETTING, AND STEWARDSHIP. INCIDENTALLY, THESE PRINCIPLES ARE APPLICABLE TO INDIVIDUAL UNIVERSITY ADMINISTRATIONS AS WELL AS TO SHARED

INSTRUMENTATION FACILITIES. THE ISSUE IS HOW TO CREATE AN INCENTIVE FOR UNIVERSITIES TO APPLY THESE MANAGERIAL TOOLS.

IN ANY CASE, THE ESTABLISHMENT OF A FORMAL JUSTIFICATION PROCEDURE GOING BEYOND INITIAL PROCUREMENT WOULD HELP ENSURE COST EFFICIENCY AND IMPROVE RETURN ON INVESTMENT NOT ONLY FOR THE PROCUREMENT OF EQUIPMENT, BUT ALSO ITS MAINTENANCE, UPGRADING, AND EVENTUAL REPLACEMENT BASED ON EXPECTED OBSOLESCENCE RATES. PROPOSALS TO ACQUIRE EQUIPMENT SHOULD BE REQUIRED TO ADDRESS QUESTIONS OF CONTINUING MAINTENANCE, TRAINING AND SAFETY FOR OPERATING PERSONNEL, PLANNED USE, AVAILABILITY OF EXISTING INSTRUMENTS, AND INCLUDE AN ANALYSIS OF ALTERNATIVES.

SETTING OBJECTIVES FOR WHAT WE EXPECT TO ACHIEVE WOULD PROVIDE BENCHMARKS FOR MEASURING AND CONTROLLING PROGRESS. JUST WHAT DO WE NEED TO MEASURE? WITH WHAT ACCURACY? HOW RAPIDLY? IN INDUSTRY, OBJECTIVES ARE CRUCIAL TO GOOD LONG RANGE PLANNING, AND THE EFFICIENT REBUILDING OF OUR RESEARCH INFRASTRUCTURE REQUIRES JUST SUCH A LONG-RANGE VIEW.

THE ESTABLISHMENT OF A STEWARDSHIP MECHANISM CAN HELP ENSURE MAXIMUM SCIENTIFIC RESULTS FOR THE RESOURCES EXPENDED. IN THE ABSENCE OF A DIRECT ECONOMIC AND COMPETITIVE FOCUS, THERE IS NEED FOR A MECHANISM TO ENSURE ACCOUNTABILITY. IN INDUSTRY, WE HOLD RESEARCHERS ACCOUNTABLE FOR THEIR INVESTMENT DECISIONS, AS WELL AS THE QUALITY AND PRODUCTIVITY OF THEIR WORK. WHILE WE DARE NOT BREED EXCESSIVE CONSERVATISM IN A RESEARCH ORGANIZATION, AN INTELLIGENTLY APPLIED CONTINUING APPRAISAL PROCESS IS NEEDED TO ALLOCATE FUNDS TO THE MOST PRODUCTIVE LABORATORIES AND WORKERS.

LET ME MAKE TWO ADDITIONAL POINTS. FEDERAL AND STATE GOVERNMENTS DO NOT NEED TO BEAR THE FULL BURDEN OF MODERNIZING INSTRUMENTS AND FACILITIES AT THE UNIVERSITIES. ALTERNATIVE METHODS OF FUNDING SHOULD BE EXPLORED. ONE SUCH ALTERNATIVE, DEBT FINANCING, HAS BEEN USED SUCCESSFULLY FOR MORE THAN 10 YEARS AT COLORADO STATE UNIVERSITY.

SECOND, THE USE OF ELECTRONIC NETWORKS TO GATHER AND COMMUNICATE INFORMATION AMONG RESEARCHERS IN A FIELD COULD HAVE A SUBSTANTIAL IMPACT ON THE EFFICIENT USE OF

INSTRUMENTATION AND DEVELOPMENT OF TECHNOLOGY. AS ONE EXAMPLE, A NATIONAL ELECTRONIC INVENTORY OF AVAILABLE INSTRUMENTS (POSSIBLY INCLUDING SOME INDUSTRIAL EQUIPMENT) MIGHT GO A LONG WAY TO REDUCE DUPLICATION AND MAXIMIZE USAGE. FURTHER, SUCH A SYSTEM COULD HELP FACILITATE AN ASSESSMENT OF THE MAGNITUDE OF EQUIPMENT AND FACILITIES NEEDS.

THESE ARE SUGGESTIONS MEANT TO STIMULATE DISCUSSION ON SOLUTIONS TO THE INFRASTRUCTURE PROBLEM. I HOPE I HAVE IDENTIFIED SOME PRACTICES ROUTINELY USED BY INDUSTRY THAT CAN BE ADAPTED FOR REBUILDING OUR RESEARCH INFRASTRUCTURE. RESEARCH IS BECOMING SO CAPITAL-INTENSIVE THAT THE USE OF PROVEN BUSINESS PROCEDURES AND TECHNIQUES MUST BE USED TO ENSURE THAT OUR INVESTMENTS YIELD MAXIMUM SCIENTIFIC AND TECHNOLOGICAL RETURN. AT THE SAME TIME, WE MUST RECOGNIZE THAT INDUSTRIAL AND UNIVERSITY RESEARCH ARE NOT AND SHOULD NOT BE THE SAME. I DO KNOW THAT IN ENCOURAGING OUR RESEARCHERS AND MANAGERS TO WORK WITH UNIVERSITIES ON THIS ISSUE, INDUSTRY HAS DEMONSTRATED A WILLINGNESS TO HELP -- AND THAT THIS HELP IS NEEDED.

Mr. **Fuqua**. Thank you very much, Dr. Sprow.

We are now very pleased to welcome back Dr. Donald Langenberg. He has been here many times before. He is currently the chancellor of the University of Illinois at Chicago.

STATEMENT OF DR. DONALD N. LANGENBERG, CHANCELLOR, UNIVERSITY OF ILLINOIS AT CHICAGO, CHICAGO, IL

Dr. **Langenberg**. Thank you, Mr. Chairman.

Let me say that it is a pleasure to be here before you again.

I am here today on behalf of five higher education associations: The Association of American Universities, the National Association of State Universities and Land-Grant Colleges, the American Council on Education, the Association of Graduate Schools, and the Council of Graduate Schools in the United States. As this committee is well aware, universities comprising the membership of these associations perform most of the academic research supported by the National Science Foundation and by the mission agencies of the Federal Government.

Mr. Chairman, I would like to begin by congratulating you on behalf of those associations, you and your panel, for undertaking this timely and thorough review of our science policy and for including in your work an examination of the longer term capital needs of research universities. We welcome this opportunity to discuss with you the universities' research facilities, capital deficit, and to offer our suggestions on how we ought to meet our future requirements.

In the interest of time, I am going to summarize my remarks, so that we might have some more time for questions.

When the National Science Foundation was established in 1950, a concern for the research capital base became an early mission of the Foundation. Beginning in 1959, the Foundation joined with the National Institutes of Health, the U.S. Office of Education, NASA, the Department of Defense, and other agencies in establishing research facilities programs designed to expand and strengthen the Nation's research capacity. NSF and NIH led the way, but the mission agencies, especially DOD and NASA, also played essential roles.

On the NSF side, there was established the Graduate Science Facilities Program. Between fiscal 1960 and fiscal 1970, the Foundation provided just under 1,000 grants totaling $188 million to assist in the construction of laboratories and the acquisition of equipment. As we face our present budget constraints, it is important to remember that the Foundation did not pay the entire cost of the facilities it helped to fund. Matching funds were required. In fact, the Foundation's contributions had a very impressive leveraging effect. The total value of the facilities and equipment acquired with NSF assistance was about $500 million, and that is better than a 2-to-1 leverage.

According to NSF, over the period 1957 to 1970, Federal grant funds for graduate science facilities totaled about three-quarters of a billion dollars. National investments from all these sources were surely several times that. Then in 1970 all Federal funding for this purpose ceased. Federal leadership receded. The linkage between federally-funded research programs and the Federal contribution to the capital facilities necessary to sustain them was broken. We reversed our commitment to stimulating capital investments in university research facilities, and our present problems began to grow.

The topic of your hearing is infrastructure. Yesterday, Dr. Dale Corson, in his testimony before this committee, defined the term infrastructure to include the people, the facilities, the equipment, the research libraries, and the institutional arrangements required to do effective research. Dr. Corson is, as usual, correct. The term "infrastructure" includes much more than the research facilities which, however, are the focus of my remarks today.

Even the term "research facilities" requires some definition. The Committee on Science, Engineering, and Public Policy of the National Academy of Sciences has just published the fourth edition of the report required by the National Science and Technology Policy Organization Priorities Act of 1976. It is titled, *The Outlook for Science and Technology, 1985.*

That report helpfully distinguishes among four classes of research facilities: national facilities like the Fermi National Accelerator Laboratory in Illinois; university-based research facilities, a new or renovated chemistry or engineering building would be an example; regional research facilities—for example, the Triangle Universities Nuclear Laboratory in North Carolina; and technology centers—as an example there, the Basic Industry Research Institute at Northwestern University.

All of these facilities are typically located at or in some association with a university or group of universities. There are important resource and policy questions surrounding each one of those classes. I would like to limit my remarks, however, to just one of them: the need to modernize university campus-based research facilities that are home to the Nation's competitive scientific and engineering research programs.

Now a few words about the dimensions of the problem: the problem, in its essentials, is quickly stated. Many of the Nation's leading universities are hampered by substantial and growing inventories of obsolete laboratories. Present estimates of the capital deficit are inadequate and they vary rather widely. We are pleased, therefore, incidentally, that this committee addressed the need for better information and analysis of the problem by including in the FY 1985 NSF Authorization Act new authority for NSF to develop a permanent analytical capability in this area. We hope the Foundation will proceed rapidly to develop this essential data base.

Now although we don't know the dimensions of the problem with any precision, there are estimates that can give us a general idea of its magnitude. There are some present estimates that say that one-half of the physical plant of all universities and colleges is more than 25 years old, and that one-quarter of it was built prior to World War II. In 1981, the AAU reported that universities were able to meet only about half of their accumulating needs to replace, modernize, and renovate their research laboratories.

Our experience at the University of Illinois confirms these earlier findings. We have just completed an audit of the condition of all university buildings excluding student auxiliary buildings—housing, unions—and also excluding our powerplants. We are talking about academic and administrative space. The audited buildings university-wide number more than 280 and they house nearly 10 million net assignable square feet, and they have an estimated replacement value exceeding $2 billion. Fifty-six percent of the buildings on the Urbana campus and 44 percent of the total on both campuses are over 50 years old. The total cost to renovate the better buildings and replace the worst is estimated at just under $600 million; that is to say, nearly 30 percent of the total replacement costs. A considerable portion of these facilities is research facilities. In summary, the University of Illinois has an immediate research facilities deficit conservatively estimated to be several hundred million dollars. Furthermore, these estimates do not include the projected requirements of new research programs. This building condition audit was carried out in terms of continuing use of these buildings for their present purposes. It does not include the estimated cost of their adaptation to those special needs of new kinds of research programs.

The Department of Defense has recently published a report that I believe confirms that these audit results are not peculiar to the University of Illinois. On April 29, the DOD, in response to an 1984 request by the House Committee on Armed Services, published a report entitled, *Selected University Laboratory Needs in Support of National Security.* I understand that copies of that report have been provided to the committee. Significantly, this report does not present information gathered from the university. Instead, it gives the DOD perspective, in particular, a research program officer in the DOD research support arm. We understand that only a small fraction of the top 100 research universities were included in each review, and, unlike our audit at the University of Illinois, which was university-wide across all fields, the DOD estimates are confined to the needs of relatively few institutions in just five disciplines which were judged essential to the Department's mission: chemistry, electronics, engineering, materials, and physics.

The services estimate that these key universities have priority needs for equipment and facilities in just these five fields of almost $700 million. The report recommends that the Department of Defense establish a 5-year, $300 million laboratory modernization program and that other Federal agencies join DOD in a Government-wide effort.

We are pleased to see that the House Committee on Armed Services already is responding to the DOD's concerns. Last week the committee increased from $25 to $200 million the funding requested by the President for a new program named the "University Research Initiative."

We hope that the members of the Committee on Science and Technology will join with the House Committee on Armed Services in securing an appropriation for this potentially important initiative at the full authorized level.

A satisfactory solution to this problem lies beyond the capacity of almost all institutions. There is required, we believe, a broader effort that must come from a well-conceived and well-coordinated national program, led by the Federal Government and again working through its six major research agencies: DOD, DOE, NASA, NIH, NSF, and USDA.

We believe there are several basic principles that ought to guide the development of a Government-wide reinvestment initiative. Let me underline the word "reinvestment." The bit of historical background that I gave suggested that there was a period when the Federal Government was investing heavily in the capital infrastructure for research in the Nation's universities. Any renewed program could be characterized as a reinvestment.

Among those are the following principles: university research and training programs supported by Federal agencies are essential to our security, our health, our economy, and our general well being.

Research and education programs of many universities and colleges are hampered by inadequate research facilities and equipment, and these institutions lack the ability to replace or modernize their facilities without the assistance of the Federal research agencies.

The capital deficit of universities is threatening the Nation's competitive position in science, engineering, and technology; thus, placing at risk our future national security, our health, and our standing in the international marketplace.

A national program to secure the necessary reinvestment in the capital base at universities is needed. Federal agencies, States, industry, and others all must participate because the Nation's needs exceed the capacity of any one sector to address them alone.

The Federal research agencies must rebuild the linkages between their research programs and the capital base by making capital investments in those academic fields and institutions that are essential to each agency's mission.

Facilities modernization programs ought to be established and developed an integral parts of each agency's research program.

Proceeding from these guiding principles, we suggest that a successful facilities reinvestment program will have at least the following characteristics:

It will provide for a sustained commitment for a period of at least 8 to 10 years.

Each Federal dollar invested will be matched, thereby at least doubling the leverage of each tax dollar.

Awards will be made competitively among qualified institutions with primary but not necessarily sole emphasis given to the scientific and technical quality of the research and training to be provided. State and local considerations will also be taken into account.

Finally, smaller, developing research universities and research-oriented colleges will be guaranteed an opportunity to compete for funds among comparable institutions, so as to provide them a reasonable chance of success.

Mr. Chairman, we believe that we can no longer defer our recommitment to the research enterprise and that we can no longer afford to turn our backs on the eroding foundations of our universities. Difficult choices lie ahead, only because these are unusually difficult times.

Some of our choices no doubt will require us to defer certain priorities in order to get on with the necessary rebuilding effort.

Saying no is never easy, but it is absolutely essential that we begin that priority-setting process.

I thank you for the opportunity to share these thoughts with you. I would be pleased to respond to your questions.

[The prepared statement of Dr. Langenberg follows:]

STATEMENT OF

DR. DONALD N. LANGENBERG
CHANCELLOR

UNIVERSITY OF ILLINOIS AT CHICAGO

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY

TASK FORCE ON SCIENCE POLICY

U.S. HOUSE OF REPRESENTATIVES

IN BEHALF OF

ASSOCIATION OF AMERICAN UNIVERSITIES
NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND-GRANT COLLEGES
AMERICAN COUNCIL ON EDUCATION
ASSOCIATION OF GRADUATE SCHOOLS
COUNCIL OF GRADUATE SCHOOLS IN THE UNITED STATES

MAY 22, 1985

Introduction

Mr. Chairman and members of the Science Policy Task Force, my name is Donald Langenberg and I am Chancellor of the University of Illinois at Chicago. Before assuming my present responsibilities, I had the honor of serving for two and a half years as Deputy Director of the National Science Foundation. I am pleased to appear before you today on behalf of five higher education associations: the Association of American Universities, the National Association of State Universities and Land-Grant Colleges, the American Council on Education, the Association of Graduate Schools and the Council of Graduate Schools in the United States. As this Committee is well aware, the universities comprising the membership of these associations perform most of the academic research supported by the National Science Foundation and by the mission agencies of the federal government.

Mr. Chairman, we congratulate you and the Panel for undertaking this timely and thorough review of our science policy, and for including in your work an examination of the longer term capital needs of research universities. We welcome this opportunity to discuss with you the universities' research facilities capital deficit, and to offer our suggestions on how we ought to meet our future requirements.

Background

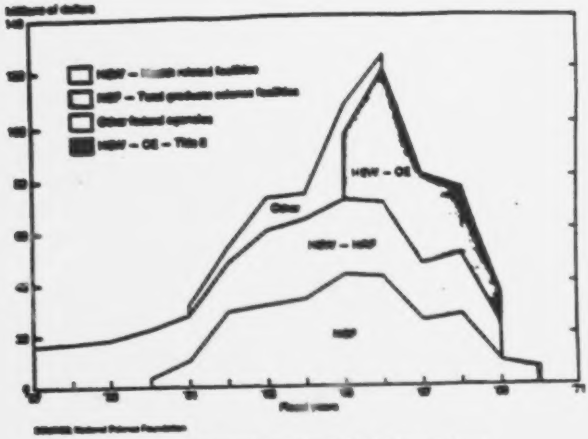
About forty years ago, inspired by Dr. Vannevar Bush and using the lessons learned during World War II, we charted a new course for our research universities in the nation's life. We saw these institutions in a new perspective, and we chose to nurture their unique research and training capabilities. We committed the resources necessary to enhance our research base and to have universities play central and indispensable roles in the nation's long-term research and training effort. With the benefit of hindsight, most now recognize the wisdom of those decisions. But it is good to remember that they were farsighted and courageous decisions in their time.

The National Science Foundation was created through a lengthy and contentious process. Many leaders of science and government differed over the appropriate role of the federal government in academic science. Some were concerned that a National Science Foundation might interfere with, rather than nurture, the free conduct of science. But, after several years of effort, the necessary accommodations were achieved, and, to the nation's benefit, the NSF was established in 1950.

A concern for the research capital base became an early mission of the Foundation. Beginning in 1959 the Foundation joined with the National Institutes of Health, the United States Office of Education, NASA, the Department of Defense and other agencies in establishing research facilities programs designed to expand and strengthen the nation's research capacity. NSF and NIH led the way, but the mission agencies, especially DOD and NASA, also played essential roles.

NSF established the Graduate Science Facilities Program. Between Fiscal Year 1960 and Fiscal Year 1970 the Foundation provided 977 grants totaling $188 million to assist in the construction of laboratories and the acquisition of equipment. As we face our present budget constraints, it is important to remember that the Foundation did not pay the entire cost of the facilities it helped to fund. Matching funds were required. In fact, the Foundation's contributions had a very impressive leveraging effect. The total value of the facilities and equipment acquired with NSF assistance was about $500 million, better than a two-to-one leverage. The programs and funding mechanisms of the agencies varied, but the policy objectives were the same--all of the agencies sought to strengthen the universities' research and graduate training capabilities.

According to the NSF, federal grant funds for graduate science facilities for fiscal years 1957-1970 totaled about $3/4 billion. National investments from all sources surely were several times that. Then, in 1970, all federal funding ceased. Federal leadership receded. The linkage between federally funded research programs and the federal contribution to the capital facilities necessary to sustain them was broken. We reversed our commitment to stimulating capital investments in university research facilities, and our present problems began to grow.



SOURCE: National Science Foundation

Figure 1. Total Federal Grant Funds for Graduate Science Facilities by Fiscal Years 1957-1970

The fruits of those original decisions confirm their wisdom. The nation can take legitimate pride in the extraordinary accomplishments of the past four decades. There is no need to recount the history for this Committee. You provided indispensable leadership for this historic effort. It is sufficient to note how those policy choices have transformed our health, our economy, our educational system and our national security. As we look ahead, we can glimpse our future as we contemplate the implications of revolutionary developments in such promising fields as biotechnology, advanced materials, microelectronics, and supercomputers. The question before us is whether we remain today sufficiently wise, and courageous, to make the inescapable and difficult choices before us.

The Meaning of Infrastructure

The term infrastructure, though widely used to characterize our concerns, is an imprecise guide to discussions of the problem and policy choices. Yesterday Dr. Dale R. Corson, in his testimony before the Committee, defined the term infrastructure to include the people, the facilities, the equipment, the research libraries and the institutional arrangements required to do effective research. He is correct. The term includes much more than the research facilities which are the focus of my remarks.

The term research facilities itself requires definition. The Committee on Science, Engineering, and Public Policy of the National Academy of Sciences has just published the fourth edition of the report required by the National Science and Technology Policy, Organization and Priorities Act of 1976 titled "The Outlook for Science and Technology 1985." The report helpfully distinguishes among four classes of research facilities:

1. national facilities, intended to serve a national, often international, research community. The report

cites the Fermi National Accelerator Laboratory in Illinois as an example of such a facility.

2. university-based research facilities; a new or renovated chemistry or engineering building is an example.

3. regional research facilities usually based at a university; the report cites the Triangle Universities Nuclear laboratory in Durham, North Carolina, as one example.

4. technology centers; these are usually located at or affiliated with universities and are tied to local or regional economies--for example, the Basic Industry Research Institute at Northwestern University.

Important resource and policy questions surround each of these four classes of facilities. I will limit my remarks, however, to just one of them: the need to modernize university, campus-based research facilities that are home to the nation's competitive scientific and engineering research programs.

The Dimensions of the Problem

The problem, in its essentials, is quickly stated. Many of the nation's leading universities are hampered by substantial and growing inventories of obsolete laboratories. In a real sense we have allowed the capital base of our research enterprise to become a wasting asset. For many years, as we stimulated investment in research with striking success, we simultaneously forced our institutions to consume their capital assets. When we abruptly stopped investing in the capital base for our national research programs, we effectively mortgaged our future, and that mortgage has now come due in institutions and states across the country.

The consequences are ominous for the researchers and students who must work in inadequate buildings with obsolete equipment. Rich opportunities to exploit new fields are being lost, many of the most promising research questions are not being addressed, excessive time is being consumed by the maintenance and repair of outdated instruments and support equipment--often because laboratories lack the necessary technical support personnel, interactions between academic and industrial researchers are being impoverished, commercially available devices for making advanced measurements are not being applied to research questions and the quality of training provided to advanced undergraduate and graduate students is being compromised.

These conditions erode faculty morale at a steady pace, and they make careers in industrial and national laboratories increasingly attractive for our brightest students. Prospective graduate students, especially highly talented U.S. citizens, now frequently opt to pursue alternative careers rather than work in inferior university environments. Half of the Ph.D. degrees awarded by our engineering schools now go to foreign nationals, many of whom return to their own countries. Our ability to attract and retain highly qualified minorities and women also is being steadily reduced.

Obsolete research equipment is one important aspect of the broader problem now widely recognized by federal and state government, by industry and, of course, by the universities themselves. Some important steps already have been taken by federal agencies, especially by NSF and DOD. But anyone who looks carefully at the equipment problem will quickly see that these efforts are only a beginning.

For example, a recent NSF survey of 43 universities found that 25 percent of equipment now in use is obsolete; only 16 percent is state of the art; half of it is at least six years old. More than 90 percent of the department heads responding reported that "important subject areas" of research could not be performed in their laboratories because they lack the necessary instrumentation. Almost half of them rated their equipment as "insufficient"; only 8 percent said their equipment is "excellent."

These findings are based on a survey of 22,300 items inventoried in three key fields: computer science, physical science and engineering. They ought to interest any who are concerned about our ability to develop new technologies, to create advanced manufacturing processes and to shorten the time necessary to transfer findings from the laboratory to new applications.

Beyond the instrumentation problem lies the ill-defined but larger, and certainly more difficult, problem of replacing and modernizing the research buildings which house our researchers, their students and their research instruments. Present estimates of the capital deficit are inadequate, and they vary widely. We are pleased, therefore, that this committee addressed the need for better information and analyses of the problem by including in the FY 1985 NSF Authorization new authority for NSF to develop a permanent analytical capability in this area. We hope the Foundation will proceed rapidly to develop this essential data base.

Some present estimates are that one-half of the physical plant of all universities and colleges is more than twenty-five years old; one-quarter of it was built prior to World War II. A 1980 report by the Association of American Universities found that the median age of research instruments in university laboratories surveyed was twice that of commercial laboratories. In 1981 the AAU reported that universities were able to meet only about half of their accumulating needs to replace, modernize and renovate their research laboratories.

Our experience at the University of Illinois confirms these earlier findings. We have just completed an audit of the condition of all university buildings, except student auxiliary buildings and our power plants. The audited buildings number more than 280, house nearly 10 million assignable square feet and have an estimated replacement value exceeding $2 billion. Fifty-six percent of the buildings on the Urbana campus and 44 percent of the total on both campuses are over 50 years old. The total cost to renovate the better buildings and to replace the worst is estimated at just under $600 million; i.e., nearly 30 percent of the total replacement cost. A considerable portion of these facilities are research facilities. In summary, the University of Illinois has an immediate research facilities deficit conservatively estimated to be several hundred million dollars. And these estimates do not include the projected requirements of new research programs. Furthermore, this building condition audit was carried out in terms of continuing use of these buildings for their present purposes; it does not include estimated costs of their adaptation to the special needs of new kinds of research programs.

A report just published by the Department of Defense confirms that our audit results are not peculiar to the University of Illinois. On April 29 the DOD, in response to a 1984 request by the House Committee on Armed Services, published a report titled, "Selected University Laboratory Needs in Support of National Security." I understand that copies of the report have been provided to the Committee.

This new report increases our understanding of the research capital deficit. Significantly it does not present information gathered from the universities. Instead it gives the DOD perspective of the problem. It provides estimates prepared by research program officers of the Office of Naval Research (ONR), the Army Research Office (ARO), the Air Force Office of Scientific Research (AFOSR) and the Defense Advanced Research Projects Agency (DARPA). The Division Directors of the Services assessed the priority research laboratory needs of the key universities in which they fund research. (We understand that only a small fraction of the top 100 research universities were included in each review.) Unlike the Illinois audit, which was university-wide across all fields, the DOD estimates are confined to the needs of relatively few institutions in just five disciplines essential to the Department's mission: chemistry, electronics, engineering, materials and physics.

The following table, "IV-1 Summary of Selected Laboratory Needs of Major University Performers of Defense Research," presents the results of the study. The Services estimate that the key universities have priority needs for equipment and facilities in these five fields of almost $700 million. The report recommends that the Department of Defense establish a five-year $300 million laboratory modernization program, and that other federal agencies join DOD in a governmentwide effort.

Data prepared by the National Science Foundation help to place

Table IV-1. Summary of selected laboratory needs of major university performers of defense research.

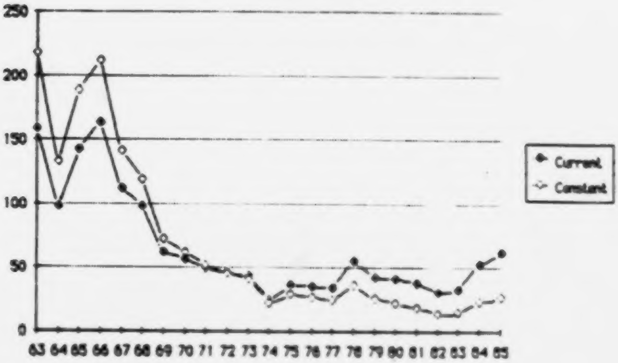
Discipline	Priority	Building Requirements (gross ft^2)	Cost ($ thousands)* Facilities	Equipment	Total Costs
Chemistry	1	35,000	5,000	14,000	19,000
	2	412,000	44,700	33,400	78,100
Subtotals		447,000	49,700	47,400	97,100
Electronics	1	130,000	49,000	33,000	82,000
	2	25,000	6,000	8,000	14,000
Subtotals		155,000	55,000	41,000	96,000
Engineering	1	296,500	36,200	39,000	75,200
	2	45,300	8,900	18,300	27,200
Subtotals		341,800	45,100	57,300	102,400
Materials	1	220,000	55,000	62,100	117,100
	2	170,000	29,000	36,400	65,400
Subtotals		390,000	84,000	98,500	182,500
Physics	1	80,000	15,800	9,300	25,100
	2	131,000	25,700	163,300**	189,000**
Subtotals		211,000	41,500	172,600**	214,100**
Summary	1	761,500	161,000	157,400	318,400
	2	783,300	114,300	259,400**	373,700**
Totals		1,544,800	275,300	416,800**	692,100**

*Numbers are rounded to the nearest $100 thousand.

**Includes $150 million for astrophysics high angular resolution imager.

the DOD findings in context. Spending by universities on R&D facilities and equipment, currently about $1 billion per year, has been relatively flat since 1968 in current dollars, and in constant dollars, declined some 60 percent during 1966-81. The federal share of the total facilities effort, meanwhile, declined from 32 percent in 1966-68 to 16 percent in 1981. In constant dollars federal obligations for academic R&D plant decreased by 90 percent between 1966 and 1983. (See the following figure.) Clearly a competitive industry would not so effectively decouple investment in its capital base from its long-term objectives.

Federal Obligations for R&D Plant to
Universities and Colleges
Fiscal Years 1963-1985
(Dollars in Millions)



SOURCE: Division of Science Resources Studies, National Science Foundation.
Figures for 1984 and 1985 are estimates.

We are pleased to see that the House Committee on Armed Services already is responding to the DOD's concerns. Last week the Committee increased from $25 million to $200 million the funding requested by the President for a new program named the University Research Initiative (URI). Through this program the DOD intends to strengthen its investment both in people and in the capital base. Graduate fellowships, faculty development programs, research instrumentation and facilities programs are proposed. In its report the Committee addressed the seriousness of the problem. The Committee's statement is attached to my testimony (Attachment A). We hope that the members of the Committee on Science and Technology will join with the House Committee on Armed Services in securing an appropriation for this potentially important initiative at the full authorized level.

A Suggested Approach

In the absence of a cohesive national effort, universities are attempting to address the capital deficit by a variety of means. Debt is mounting in many institutions as they borrow funds, use available bonding authorities, leverage available funds with other private and state funds, and cost-share with other institutions. Certainly the creative energies of universities must be tapped to their capacity. I believe most already are stretching their imaginations and resources to the prudent limit, and sometimes beyond.

A satisfactory solution lies beyond the capacity of almost all institutions. That broader effort must come from a well-conceived, well-coordinated national program led by the federal government, again working through its six major research agencies: Department of Defense, Department of Energy, National Aeronautics and Space Administration, National Institutes of Health, National Science Foundation, and United States Department of Agriculture.

We believe that several basic principles ought to guide the development of a governmentwide reinvestment initiative. Among these are the following:

- University research and training programs supported by federal agencies are essential to our security, our health, our economy and our general well-being.

- The research and education programs of many universities and colleges are hampered by inadequate research facilities and equipment, and these institutions lack the ability to replace or modernize their facilities without the assistance of the federal research agencies.

- The capital deficit of universities is threatening the nation's competitive position in science, engineering and technology, thus placing at risk our future national security, our health, and our standing in the international marketplace.

- A national program to secure the necessary reinvestments in the capital base of universities is needed; federal agencies, states, industry and others all must participate because the nation's needs exceed the capacity of any one sector to address them alone.

- The federal research agencies must rebuild the linkages between their research programs and the capital base by making capital investments in those academic fields and institutions that are essential to each agency's mission; facilities modernization programs ought to be established and developed as integral parts of each agency's research program.

Proceeding from these guiding principles, we suggest that a successful facilities reinvestment program will have at least the following characteristics:

- it will provide for a sustained commitment for a period of at least eight to ten years;

- each federal dollar invested will be matched, thereby at least doubling the leverage of each tax dollar;

- awards will be made competitively among qualified institutions with primary but not necessary sole, emphasis given to the scientific and technical quality of the research and training to be provided; state and local considerations also will be taken into account; and

- smaller, developing research universities and research-oriented colleges will be guaranteed an opportunity to compete for funds among comparable institutions so as to provide them a reasonable chance of success.

Conclusion

Mr. Chairman, we believe that we no longer can defer our recommitment to the research enterprise. We can no longer afford to turn our backs on the eroding foundations of our universities. Difficult choices lie ahead only because these are unusually difficult times. Some of our choices no doubt will require us to defer certain priorities in order to get on with the necessary rebuilding effort. Saying no is never easy, but it is absolutely essential that we begin that priority-setting process.

Thank you for the opportunity to share these thoughts with you. I will be pleased to respond to your questions.

99th Congress
1st Session
| HOUSE OF REPRESENTATIVES |
Report
99-81

(May 10, 1985)

DEPARTMENT OF DEFENSE AUTHORIZATION ACT, 1986

REPORT

OF THE

COMMITTEE ON ARMED SERVICES U.S. HOUSE OF REPRESENTATIVES

ON

H.R. 1872

together with

ADDITIONAL AND DISSENTING VIEWS

p. 119:

The following are several significant recommendations made by the committee in the research and development area.

—Addition of $175 million to the Department of Defense request for $25 million for the University Research Initiative program is recommended for authorization. The number of U.S. students enrolled in graduate school has declined severely during the past decade; university facilities and instrumentation are, in many instances, obsolete; graduate students are not being exposed to the kind of high technology projects that are important to national security during their graduate training; and a better exchange of ideas and technology is needed between our universities, Federal laboratories and industry. This initiative is strongly supported by the White House, by the National Science Foundation and the scientific community.

UNIVERSITY RESEARCH INITIATIVE

Committee recommendation

The committee recommends additional authorization of $175 million to the Department of Defense request for $25 million for the University Research Initiative (URI).

Basis for committee action

The purpose of this initiative is to maintain an adequate science and technology base essential to our national security objectives. The maintenance of an adequate technology base is a national priority with important economic as well as military implications. Accordingly, the need to ensure a viable technology base within the universities throughout the country is the responsibility of all Federal activities including the Department of Defense and the National Science Foundation.

The committee is concerned that the enrollment of U.S. university graduate schools in critical areas consists principally of foreign nationals. U.S. industrial salaries offered to scientists, engineers and others in critical skills are so attractive that little incentive exists for those with bachelor degrees to continue in graduate education. The U.S. university base has been on the decline; university facilities and instrumentation are in many instances antiquated; graduate students are not exposed to many high technology areas until they begin their industrial careers; and the exchange of innovative ideas between the universities and the Federal laboratories has declined.

The committee believes that the Department of Defense must contribute its fair share toward preserving our industrial base and ensuring a future talent pool from which to draw. Accordingly, the committee recommends an addition of $175 million to the department's request for $25 million to begin the university research initiative. Section [illegible] of the bill specifies that the authorization be used only for this purpose. This recommendation has been strongly supported by the President's Science Advisor, the American Association of Universities and representatives from the Department of Defense. The committee intends that the authorization be used:

—to extend the research fellowship program for U.S. students to encourage graduate study;

—to modernize university laboratories and instrumentation;

—to initiate as early as possible high technology programs such as tunable free electron lasers for medical applications, very high speed integrated circuit technology and other areas that a graduate student would not normally encounter until he or she entered industry; and

—to establish a greater exchange of ideas and to enhance the working relationship between Federal research centers and laboratories and the universities.

The committee was advised by the President's Science Advisor that the recommended level of authorization is essential and that it was to be included in the Department of Defense fiscal year 1986 budget request but was inadvertently deleted during the budget process. The committee expects that the Department of Defense will request the appropriate level of authorization for fiscal year 1987.

ATTACHMENT A

PANEL DISCUSSION

Mr. **Fuqua**. Thank you very much.

Let me thank all of you, and particularly, Dr. Langenberg, for the comment about the University Research Initiative that the Armed Services Committee has put forth. We have not had a chance to discuss that with them and I am very pleased to see the forward-looking attitude they have taken in this area and with considerable increase over what had been recommended by the President.

You can rest assured of my personal support when that comes to the floor for authorization as well as the appropriations process. I think it is very important to support that program.

Dr. Hensley, in your opinion the growth in the number and the cost of research support personnel—I think you included about one-fourth research and about three-fourths support personnel—is that attributed to the growth of government regulation and so forth?

Dr. **Hensley**. A portion would be, the accounting portion, but very small. It is really the changing science structure that is changing on the universities.

Mr. **Fuqua**. The management of the research and support personnel is principally a matter for the universities to manage themselves.

Dr. **Hensley**. That is correct.

Mr. **Fuqua**. Is there anything that the Federal Government can do to try to reduce that escalating cost of research infrastructure?

Dr. **Hensley**. I don't think it is reducible. I think it is going to continue to grow.

The accounting procedures and management procedures that are currently in the universities are in need of a reassessment by institutions themselves. Some place along the way a system of prioritization, what they will do, and a way of looking at where they are spending their money has to occur. Academics will have to resist this, the same way they have resisted time and effort reporting. It is very difficult to get a handle on exactly where money is going in university research unless you do it on a project-by-project basis. The infrastructure as a whole is not costed out to a project.

Infrastructure is supported at a departmental level usually or a central facilities level without a system of chargebacks unless it is for computers, so it becomes very difficult as an accountant to look at it and find out where the money is going specifically. University academics want the support but they also do not want to make the effort as far as paperwork is concerned to give you some kind of audit trail back to where those facilities are supporting a particular project or a particular piece of research.

Mr. **Fuqua**. What impact would it have for changing the accounting procedures, particularly depreciation or amortization of equipment and buildings as suggested to us yesterday by one of the witnesses?

Dr. **Hensley**. I think it would have——

Mr. **Fuqua**. Some 50 years to 25 years more realistically.

Dr. **Hensley**. I think that would help. Again, in supporting science and research that we will need it would mean changing our models within our institutions about how we will do this. However, it would be a step forward as far as I am concerned.

Dr. Langenberg may have a different opinion.

Dr. LANGENBERG. I think it would be a helpful recognition of the realities of lifetimes of research laboratories and research instrumentation. I do not think it provides the solution to our present problem.

Mr. FUQUA. Mr. Smith, you mentioned in the report you had private support. How much of that is going for basic research versus general education? Do you have a breakdown of that?

Mr. SMITH. No, Mr. Chairman, we do not have a breakdown following that particular line; 15 percent is what we show the institutions reporting to us as support for research. That is the only clue we have here.

The general categories that are recognized by both the accounting people and fund-raising people with whom we have contact correspond to those various purposes we show.

Mr. FUQUA. What I am trying to get at is this: you indicated a number of colleges and the amount of money they raise privately, from corporations, nonalumni, et cetera. Of course, I have been involved in that business somewhat, too, being an alumnus of a school and serving on the foundation. Some of that goes for scholarships that may not be in basic research but other areas. Not all of it is in what we call basic research. It may go into other functions. Some of it also may go to support eminent scholars, Chairs, and so on. I wondered whether there were some kind of breakdown as to how much was going in each direction or whether those figures were available. I am not sure they are.

Mr. SMITH. They are not available in quite that form. We do know about 70 percent of all the funds received by all colleges designated by a variety of things would be a general designation—used by the college for student aid, any kind of student aid, graduate, undergraduate, minorities, it can be used for those students who have particular financial needs, or a recognition for scholastic excellence. It can be used in any way they want. Other funds can be used for endowed Chairs. Some funds go directly to academic departments.

Mr. FUQUA. That is right.

Mr. SMITH. They may be restricted as far as the university is concerned to the chemistry department, engineering school, medical school, but unrestricted by the dean of that school. Undoubtedly, some of those funds that are likely funds designated for capital purposes ultimately wind up used for research or research infrastructure. There is no way to trace it down because these are not clear-cut categories.

Mr. FUQUA. Dr. Sprow, you mentioned four or five things universities do in teaching—new knowledge, and so on.

Dr. SPROW. Correct.

Mr. FUQUA. The one thing I thought was missing which I thought was very important was that of teaching. It is not necessarily the genesis of it because it starts in the home, secondary and elementary schools and graduate schools where you really have the basic training mechanism for future scholars and researchers and people who serve in Congress and whatever. I feel very strongly about this and I made that point many times. That is where we train people and these are the people we will need in society. Perhaps that can be No. 6.

Dr. **Sprow**. That goes along with 1 through 5. The teaching is critical from an industrial perspective. I think from my own observation this problem we are talking about, the equipment, instrumentation and infrastructure problem is at its most critical in teaching facilities, particularly in the undergraduate activities in the universities. It is the undergraduate engineering lab, undergraduate chemistry lab where this situation we are talking about is really critical.

Mr. **Fuqua**. You also mentioned using business management procedures and techniques developed in the industrial sector to improve the effectiveness of infrastructures. Based on your own observations and experience, what has kept the universities from doing that? Are there cases, institutions, or other situations where there has been significant progress made in trying to apply these procedures?

Dr. **Sprow**. The current system with the great majority of the funding going to individual researchers just generally works against the application of a great deal of management techniques. University people, faculty members, and researchers are an independent breed, are thankful they are, are not all conservative types like us folks in industry. I think when you have a system that by and large allocates sums to a group of independent people the chances to apply management techniques in an across-the-board way to maximize sharing and maximize planning or obsolescence and looking at ways to tie together research activities electronically and through computing, it is sort of like pushing the wrong end of the straw. It never will get through as long as that is the fundamental mechanism.

That mechanism has a place. It has produced some tremendous research. The cost of the equipment has gotten to the megascale—supercomputers, advanced physics equipment. That old mechanism and independence which is inextricably a part of it I do not think will solve the problem.

Mr. **Fuqua**. We discussed this yesterday briefly from the academic standpoint. One of the questions that comes to mind, and it has been mentioned in some of the conversations we have had before the task force, that back when we switched somewhat from the block grants, larger grants, more individual oriented research programs, we tend then to remove long-range planning and so forth for infrastructure. You mentioned 1970. There were some after that time, I think. The National Science Foundation has centers of excellence awards which worked very effectively. They were very beneficial to all concerned.

Dr. **Langenberg**. That is correct.

Mr. **Fuqua**. Do you think that has contributed part of the problem?

Dr. **Sprow**. Now that I have the mike, on the centers, I think there is a key philosophical decision which has to be made when such centers are set up, and that is not to let the organization that is geographically responsible for the center dominate the activities in the center. If you set up a center at the University of Utah and make it so difficult for researchers not at that university to participate at the university it is—I am not picking on Utah but picking them out of the air—if you make it so difficult for people outside that geographic area to participate, the center is of no use. You have to work at that from the front end to be sure there is an advisory board, active participation of proposals and research from outside the host university.

Dr. **Langenberg**. If I may, a couple general comments on the management question. I think this is indeed a serious question. Universities need to pay more attention than they have in the past to the managing of universities. They are different from industry. They are managed from the top down only to a degree. They are managed to a substantial degree by the individual faculty and individual researchers. A colleague of mine defines a faculty member as someone who thinks otherwise. That is, I think, a very true definition.

As has been pointed out, when they are equipped with their own funds from NSF, NIH, through a grant which they consider to be their own, just like the fact the university is the grantee, it tends to be very difficult to manage the process in any kind of a coherent way. One has an individual group of entrepreneurs, if you will.

Nevertheless, because they are forced to do so, I think more and more the universities, the leading universities, are beginning to develop quite sophisticated management systems. They are not exactly like those in industry. To some degree they might be said to rely on some of the consensus development or collective management techniques that we sometimes look at our Japanese colleagues and wonder whether they are using those better than we are in industry. In some sense they are a bit like that. There are many universities with strong management systems.

I also believe that larger research systems, had they been centers, centers of excellence awards, had they been Materials Research Laboratories, centers in which the funding depends on the bringing together of many different faculty researchers, many faculty students, and post-doctorates, institutions requiring management, they do tend to enhance and promote the notion that to a degree even the research process at a university can be managed to our advantage, financial and otherwise.

Dr. **Hensley**. I would like to address that issue, also. Universities have developed centers. They have developed their own centers. If you were to look at the directory for centers and institutions, you would find there has been a large growth since 1960 from close to 1,800 up to 5,500 at this time.

There was a huge growth in centers and institutes during the 1960's and seventies at all institutions. These were not necessarily funded or started by the Federal Government. They were started by the institutions themselves. In some cases material science centers were started by the National Science Foundation funds, but other types of centers have been started because they have recognized a disciplinary or regional need to establish that center at that particular institution.

More moneys are coming in to these centers and they have grown from an average size of about 18 people per center up to where there are 63 on the average size of each center. Therefore, the composition within institutions is changing.

If you look at the National Science Foundation statistics as to where money is going, you will see more money is going to centers percentagewise, an increasing amount of money into center and institute-type of development rather than individual areas. Institutions are putting together management techniques that will meet the changing needs of the society and they are doing it in their own way in what they call their centers, and these things are relatively small—100 people or so. That is the way they are handling their response to better management.

Mr. **Fuqua**. Before I call on Mr. Bruce, we may have some additional questions. I will have to excuse myself. We may have additional questions to submit to you. We would appreciate your responding to those questions.

Mr. **Bruce**. Welcome, Dr. Langenberg. I am glad to have you here.

One of the things in your testimony you brought forward is that there should be matching grants. You mentioned $700 million in immediate needs and perhaps another $300 million over a 5-year period.

Dr. Hensley, I noticed in this morning's paper that Texas colleges and universities are falling on to hard times because of the lack of oil revenue. Could the universities in this country try to come up with matching dollars on a $1 billion research program? Could you match that dollar for dollar?

Dr. **Langenberg**. I believe they could. There is almost no incentive like money. If Federal money would flow only in response to a match from another source, I think if you look for the public institutions that States support, prototypes of a kind of program that could be looked to for possible matching funds for the public institutions, if you look at the very substantial numbers we have heard about for private, particularly corporate, giving, yes, I think the universities could come up with matching funds. They have in the past and I think they could now from one source or another.

Dr. **Hensley**. I would concur with that opinion.

Mr. **Bruce**. I came from another science and technology meeting. We talked about transfer of information from research facilities. There is a possibility we will have legislation pending to allow a 15-percent royalty program, having researchers participate in patents and licensing provisions. Down the road, would that work if these research facilities were private individuals who would receive a portion of the proceeds from licenses or patents?

Dr. **Langenberg**. That is presently the case in most places I know of. Where there is an invention and where the university in one way or another uses the patent, the faculty researcher normally participates in the proceeds.

Mr. **Bruce**. Does the university realize itself anything?

Dr. **Langenberg**. Yes, it is shared and often shared among the university and inventors, department or center and then the university.

Mr. **Bruce**. Our proposal is to do that with Federal laboratories. Do you think that might be successful?

Dr. **Langenberg**. It might very well be successful, yes.

Mr. **Bruce**. Thank you, gentlemen, for your testimony today.

The task force stands adjourned subject to the call of the Chair.

[Whereupon, at 12:10 p.m., the task force recessed, to reconvene on Tuesday, June 10, 1985, at 9:30 a.m.]

[Questions and answers for the record follow:]

ANSWERS TO QUESTIONS
FOR THE
TASK FORCE ON SCIENCE POLICY
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

PREPARED BY

DR. FRANK B. SPROW
VICE PRESIDENT
EXXON RESEARCH AND ENGINEERING CO.

NOVEMBER 14, 1985

1. Q. We have often been told that a general concern which industry has about today's science and engineering graduates is that they are trained on obsolete research equipment in comparison with the more up-to-date equipment they will be using in industry. How does industry manage to acquire and make available to their research staff the most modern equipment, and what lessons can government and the universities learn from industry in this area?

   A. The principles employed by industry for purchasing research instruments are the same as those used when considering other significant investments. To ensure that research results are obtained in a timely and cost-efficient manner, we make certain that all the alternatives to achieving research results are evaluated prior to purchase. Government and universities should consider separating equipment costs from other costs when analyzing proposals, and require investigators to offer alternatives to purchasing additional new equipment for achieving research results. This should help ensure that excessive equipment is not purchased, and that the available funds are channeled to state-of-the-art apparatus.

2. Q. You have made the suggestion that in most areas of research a threshold exists between when each researcher should have his or her own instrument and when an instrument should be used by a group of researchers. In the absence of the recognition of such a threshold by the universities, can and should the government science agencies develop and establish such thresholds?

   A. Yes. Factors that should be considered in establishing such a threshold include the cost of the equipment, ease of operation, calibration repeatability and expected time of usage.

3. Q. You observed (page 7 of your prepared testimony) that, in your view, the "exact size of the instrumentation deficit does not really matter. The problem is a major one." Would you not agree, however, that for us in the Congress, where the allocation of scarce resources and the matching of needs to resources is an important function, there is a compelling requirement to have estimates of the infrastructure needs that are as accurate as possible?

   A. Yes. A reasonably accurate assessment of the cost to rebuild our research infrastructure is important for establishing priorities for the allocation of available resources. However, before commissioning new studies, government should review the already published data to be certain that it is inadequate. My impression is that it is sufficient.

4. Q. You noted (bottom of page 7 of your prepared testimony) that competition for limited funds combined with the decision-making system involving peer review has often led to the specific denial of funds requested for instrumentation. Do you mean the denial of proposals specifically for instrumentation only, or do you mean the denial of instrumentation funds when they are part of a research proposal?

   A. The denial of instrumentation funds when they are part of a research proposal. Researchers frequently have to request equipment for two or three years before it is granted. Routine but essential instrumentation is frequently cut from research grant awards on the sometimes incorrect premise that instruments are readily available from other sources. As a consequence, researchers may be forced to use less effective, obsolete equipment which slows the pace of their research. Further, researchers may not request needed instruments in their research proposals because they fear the funds necessary will jeopardize approval of the basic proposal.

5. Q. You made the observation (page 11 of your prepared testimony) that "In industry...investment in equipment presents no hurdles - if it is justified, it is purchased." Why, in your opinion, have government agencies and the universities not been able to do the same?

   A. Research programs in the private sector are justified on economic return, and programs surviving this selection process are appropriately supported with manpower and equipment. Government and universities appear to have difficulty in making hard choices and narrowing programs down. For example, the NSF and DOE have a history of opting to provide low levels of funding for many investigators versus adequately funding fewer projects. Industry's capital and equipment investment tends to be high, while manpower is tightly stewarded. The tendency within government and universities seems to be to favor projects which employ large numbers of researchers rather than equipment.

6. Q. Are there, to your knowledge, any instances where government agencies or the universities themselves have successfully established mechanisms for holding researchers accountable for investment decisions, as is being done in industry (page 15 of your prepared testimony)?

   A. Although research proposals are subject to extensive review prior to approval, I know of no formal stewardship mechanism for holding individual investigators accountable for the quality and productivity of their work.

7. Q. The debt financing method has been explained in detail before this Committee in previous hearings. What are the reasons, in your experience, why that financing method has not been more widely used in the universities?

   A. University administrators tend to be concerned with the risk involved with debt financing. Incurring debt for the purchase of equipment is uncommon, and may in some cases be prohibited by state law. Instrumentation is so closely tied to the researcher that his or her leaving the institution could render the equipment nonusable. The university could be left with interest payments but no offsetting income stream from a sponsoring agency, etc.

   Federal regulations, as represented by OMB Circular A-21, do not allow interest payments as costs which will be funded by government grants. Therefore, universities seek to avoid interest costs, as the majority of their funding for research comes from government sources. Additionally, universities are nonprofit operations; consequently, the tax deduction associated with interest costs does not provide the same tax reduction incentive as in a profit-oriented industrial organization.

8. Q. It has been suggested that the allowances under the indirect cost system in OMB Circular A-21 have too long write-off times to realistically allow for the replacement of buildings and equipment. For example, the use charge for laboratories is now based on a 50-year life, whereas industrial practice is said to be to write off laboratories on a 20 to 25 year basis. What are, in general, the practices in industry with respect to write-off periods for buildings and equipment?

   A. Industry typically follows tax depreciation schedules as set forth by ACRS, namely 18 years for buildings and 3 years for equipment.

9. Q. Certain tax provisions now are intended to encourage industry to donate research equipment to the universities. Do we have any data on how much such equipment is being donated to the universities?

   A. To the best of our knowledge no compilation has been made of the aggregate. I am concerned that such donations do not typically include funds to maintain the equipment, and this can be a substantial burden to the receiving organization.

10. Q. Is the incentive on industry to donate research equipment to universities having the effect that modern equipment is being given to universities, or is it in fact obsolescent equipment that reaches the universities when industry replaces its own equipment with more up-to-date instruments?

A. The 1981 Economic Recovery Tax Act (ERTA) contained a provision encouraging corporate donations of instrumentation to institutions of higher learning. This provision allowed a deduction equal to cost plus one-half of the difference between the market value and cost. We believe the ERTA incentive has encouraged the donation of badly needed, modern computer equipment to universities; however, it appears to have had little impact on corporate donations of other types of modern instruments.

We should point out that the ERTA provision provides an incentive for equipment donations by manufacturers, but offers no incentive for industry research organizations to donate equipment, nor does it offer an inducement for manufacturers to provide funds for maintaining the equipment they donate.

11. Q. How many scientists and support personnel will be housed in the $200 million research facility which your company has just completed? Is this facility paid for through charges to the company's operating divisions, that is, through some form of overhead payments, or through other means? To what extent is justification for such a large facility based on forecasts of specific benefits versus more general forecasts of the expected but unpredictable benefits of scientific research generally?

A. At present, about 800 scientists and support personnel are housed in our Clinton, New Jersey, research facility. Operating costs, including rental of the facility from its owner, Exxon Capital Corporation, are borne by Exxon and its affiliates. Justification for use of this new facility is based on the realization of specific benefits, i.e., safety, efficiencies of consolidating activities, upgrading of high maintenance equipment, etc., as well as on intangible factors associated with research productivity and growth potential.

Questions for Dr. Donald N. Langenberg

1. It now appears highly likely that the size of the pie from which all federal research support must come will remain fixed in the foreseeable future, or only expand slightly. If that is the case where, within that total research budget, can we, in your opinion, make modest decreases in funding levels in order to provide the resources for the needs of the infrastructure at the universities?

1. Under the assumption that total federal funding for University research will remain essentially constant, I would support a general all-agency increase of funding for infrastructure needs. This would obviously have to occur, given the assumption, at the expense of other programs. Within the resource pool available for non-infrastructure needs, I think it is essential to continue to apply the criteria presently used by the R&D funding agencies, rather than target particular areas to assume the full cost of infrastructure funding. The need is very real, in my opinion of the highest priority, and broadly distributed across the science and engineering disciplines and the universities which foster them. The burden of meeting the need should be spread correspondingly broadly.

2. In both cases of infrastructure need which have received special attention in the last few years, instrumentation and buildings, the problem has been presented in terms of crisis suddenly being upon us. How could this occur without anyone in either the universities or the government science agencies detecting that a gradual decline was taking place?

2. Neither the decline in instrumentation nor that in buildings escaped detection by some in the universities and government science agencies. In the case of instrumentation, the public alarms go back to NAS/NAE/NRC reports in the early 1970s. It is, however, a common human characteristic to postpone going to the doctor until one has a severe pain. Or, in the words of a maxim taught me by an old Washington hand: When the practitioners in a field encounter real difficulties, it's possible there's a little problem. When people in related areas begin to suffer the consequences, there probably is a real problem. When the media and the politicians finally find out about it, WE HAVE A NATIONAL CRISIS!!!! Neither the instrumentation nor the buildings element of the infrastructure problem is what I could honestly call a crisis in the sense that if they're not completely solved this year the Nation will fall. Both are, however, very serious problems which have taken many years to reach their present level, will surely get worse in the absence of any serious attack, and will take years to solve with a serious attack. Each has become a "crisis" simply by crossing a certain threshold of general awareness. This effect, like so many in human behavior, is highly nonlinear.

3. One approach to the federal role in providing support for research infrastructure needs is to put in place individual, categorical programs in response to the needs in each area. We already had special programs in several government departments addressed to the instrumentation needs and the supercomputer needs. Should we expect a proliferation of such categorical programs every few years, or has the time come to find a more comprehensive solution to all infrastructure needs?

3. It is always time to seek comprehensive generic solutions to problems. In the case of the infrastructure problem, the possibility of finding such a solution is certainly worthy of pursuit. Unfortunately, however, identification and adoption of such a solution would, in my view, require that the federal government take an unprecedented step. It would have to embrace publicly and explicitly the notion that it has a long-term interest in the health and vitality of the nation's research universities. That would be a position radically different from the government's present stance of turning to the research universities for research and other services mainly on a selective case-by-case basis. Since I doubt the federal government would be either willing or able to make such a radical shift of position, I believe problem-oriented programs, i.e., categorical programs, are the only practical solution. They're not ideal, they don't go to the root of the matter, but they work, after a fashion, and they're better than nothing.

4. Do you have any thoughts on the suggestion that use charges be based on significantly shorter life times, for example, that instead of basing building use charges on a 50-year life (equal to 2% per year), they be based on, say, 25 years (4% per year use charge).

4. Yes, and it's a simple thought. The practical lifetime of a research laboratory building doesn't remotely approach 50 years. Its steel frame or its concrete floors may survive long, but as an environment for state-of-the-art research it's not likely to go more than 20 years without needing major changes. The government needn't rely upon an academic for such a judgment. It need only consider what kind of research it was supporting in 1935, and where it was being performed, and compare that past with the present. Changing use charges to a shorter-life basis would be no more than a recognition of reality.

5. A witness suggested recently that "For most of the decade of the 1970's and into the early 1980's the universities themselves behaved largely as dependents of the government, abdicating their responsibility for infrastructure and biding their time until Federal facilities programs were resumed." In your view, can anything be done to bring about a change in this attitude on the part of the universities?

5. Yes, but it won't be easy. This academic would be among the first to concede that our research universities, with a few exceptions, have not recognized and accepted the implications of their accession to research university status and their consequent partial federalization. In my answer to Question 3, I suggested that the federal government often behaves as though it still thinks it's in the business of farming out research in micro- and mini-projects to university job shops. Not surprisingly, in response the universities behave as though they were job shops. The notion that both the government and the universities are committed to a long-term partnership seems to have scant acceptance on either side. Attitudes on both sides can be changed, but like any change in basic attitudes, it'll take a lot of time and effort, backed by evidence of solid commitment on both sides.

6. We have occasionally had suggestions, from the GAO and others that all or part of the indirect costs be paid to the university on the basis of a fixed percentage of the direct costs rather than on the basis of detailed audits and negotiations. In your opinion, what would be the advantages and disadvantages of such a fixed percentage rate for the indirect cost coverage, and specifically, would it be helpful to the universities in giving increased flexibility to the acquisition of the infrastructure items?

6. Whether an indirect cost rate "fixed" in whole or in part would have any advantage would depend strongly on who fixed it and on what basis. Indirect costs generally are real and necessary costs attendant on the conduct of research. The federal government's present policy of reimbursing all research-related indirect costs is, in my view, just and fair. The persistent problems associated with indirect costs result from the difficulties of identifying and justifying research-related indirect costs in the academic research environment where research is conducted in close relationship with other functions. In such an environment, some elements of research-related indirect costs are relatively easily isolated and accounted for, and some are not. The most prominent example of the latter is the so-called departmental administration cost. It is this element which has engendered the debates over faculty effort reporting. I think it possible that some accommodation might be reached between the federal government and the research universities in which the departmental administration cost element might be "fixed" by mutual agreement in exchange for the elimination of effort reporting and other forms of detailed accountability with respect to this cost element. Where research-related indirect cost elements can be more simply identified, they should be so identified and reimbursed. We should resist the temptation to cut the Gordian knot by picking some overall indirect cost rate out of a hat and "fixing" it. Whether that rate were high or low, it would be wrong for at least one partner in the government-university partnership and give rise to continuing strains in the relationship.

There is no necessary connection between a fixed indirect cost rate and "increased flexibility to the acquisition of the infrastructure items." If the government and the universities could agree on realistic infrastructure use charges and on a mechanism for allocating them to future infrastructure acquisitions, the indirect cost system could provide a long-term solution for at least part of the infrastructure problem, as implied by Question 3. However, such a mechanism would obviously increase indirect cost rates significantly. A great deal of political groundwork would have to be done both in the government and in the universities to make this palatable.

7. Apart from the question of the effective life of buildings, laboratories, and equipment, to what extent have the universities been setting aside the use charges as reserves against future replacement needs?

7. In the absence of good information about the practices of universities other than my own, I really can't answer this question adequately. However, I doubt that a careful study would reveal that most universities have been setting aside use charges in reserve against future infrastructure needs. If that is the case, I would agree that this is a failing which ought to be corrected in any future reform of the indirect cost system. I would assert, however, that it is an understandable failing given the absence of any real correspondence between presently allowable use charges and the real costs of recurring infrastructure needs.

8. **An estimate by the government auditors of indirect costs suggests that over the period 1972 - 1984 a total of just over $1 billion was provided in use charges to the universities. To what extent can we account for the application of those funds to construct new buildings, and can we expect those charges in the future to provide a significant fraction of the needed funds for that purpose?**

8. I suspect it would be very difficult to establish a one-to-one relationship between use charges provided over the 1972-84 period and new building construction during that period. As for the future, the following order-of-magnitude estimate suggests, to me at least, that reimbursed use charges at the rate estimated for the 1972-84 period would provide only a very small fraction of the real needs. There are between 50 and 100 universities in this country with substantial levels of federally funded research. At the 1972-84, rate that implies use charges in the neighborhood of $1-2 million per year per university. My experience in two universities suggests that the annual recurring cost for maintenance, renovation, and replacement of research facilities exceeds that level by a factor approaching ten!

9. **You suggested that the funding of university infrastructure needs be done on the basis of matching funding by the Federal Government. What other sources do the universities have to match the federal funds?**

9. The other sources are state tax funds (available in most cases only to public universities), and gifts from private donors, either direct or via endowment income resulting from prior gifts. In a properly designed use charge system, it might be possible to derive matching funds from the sale of bonds backed by the promise of future use charge income. The latter would, of course, simply transfer most of the cost to the federal government, spreading it over many years.

10. **How can we, in your view, ensure that the financial contribution of the Federal Government, if it is done a project funding, does not, in effect, serve as a disincentive to the other partners, including industry, the states, and private donors, to contribute financially?**

10. There is really no way to ensure that; there are no absolute guarantees in life. However, I would suggest that any federal fears on that score can be allayed by looking at the actions of industry, the states, and private donors in recent years. In the face of reasonably stable, if not munificent, federal support for university research, industry has been increasing its support for university research at a faster rate than any other contributor. This has certainly happened in part because the universities, driven by the need for more dollars than the federal government can provide, have been pursuing industry support more aggressively. But I am convinced that it has also happened because both the universities and industry have become more aware of the importance of stronger university-industry linkages, and because the federal government has found ways to encourage these in many of its own programs. Many states, in greater awareness of the connection between their economic development and their research universities, have initiated new research support programs. One example is the Benjamin Franklin Partnership in Pennsylvania. Finally, gifts from private donors have been increasing at a substantial rate across the country. If the federal government can avoid slaughtering these several golden geese in the cousre of reforming its tax law, I would anticipate no abatement in these trends. In short, while I expect the federal government to continue to provide the majority of the support for university research, absent major course changes, I see no reason to fear that the other patrons of university research will use the federal government's participation as an excuse to abdicate their responsibilities.

THE FEDERAL GOVERNMENT AND THE UNIVERSITY RESEARCH INFRASTRUCTURE

Financing and Managing University Research Equipment

THURSDAY, SEPTEMBER 5, 1985

House of Representatives,
Committee on Science and Technology,
Task Force on Science Policy,
Washington, DC.

The task force met, pursuant to call, at 9:30 a.m., in room 2318, Rayburn House Office Building, Hon. George E. Brown, Jr., presiding.

Mr. Brown. If we may get underway here, we will be able to get our business taken care of.

The chairman, Mr. Fuqua, regrets that for personal reasons, personal matters will keep him away from the hearing, at least for a portion of the morning. He has asked me to substitute for him briefly.

I would like to get you warmed up by making brief opening remarks, if I may.

In the late 1970's, the research community in this country became aware that a gradual and apparently widespread deterioration in university research instrumentation was going to take place. In spite of earlier assumptions that funds for such equipment was routinely being provided as grant moneys, the instrumentation base was said to be in danger of becoming seriously outdated. In particular, it was noted that researchers in American industry were much better equipped and that in some cases industry was unhappy with recent Ph.D. graduates that they hired from many universities because they had received their training on obsolete research equipment.

At that time, about 5 or 6 years ago, very little in the way of hard solid data was available about the current status and future needs of research instrumentation. The Government agencies and the committees of Congress were forced to respond based on scattered anecdotal evidence, and there was no way of knowing how good the situation actually was. Nor was there available any careful analysis to the extent to which the Federal Government's response was meeting 20 percent or 80 percent of the actual need for new instrumentation.

Today we have before the task force the principal authors of the first major comprehensive study of the research instrumentation question. Jointly funded by a number of the affected Federal agencies, it was conducted by three of the leading university associations: the Council on Governmental Relations, the National Association of State Universities and Land-Grant Colleges, and the Association of American Universities.

The strength of this study is its comprehensiveness and its basis in data and data analysis. It's comprehensive in that it covers all the sources of instrumentation funding, including not only the Federal Government but also State governments and private industry. It also covers a wide variety of funding mechanisms, including various forms of debt funding. Furthermore, it builds on previous, more limited studies and includes, as well, data from a series of field visits made by the members of the study team.

I will note, however, that the study may also suffer from some weaknesses. It was conducted by the organizations and through interviews with many individuals who themselves have a strong and direct interest in research and research instrumentation. It's also clear that the study raises a number of important questions to which answers are not totally obvious. Nevertheless, we look forward to today's testimony and discussion, and we welcome the distinguished panel members of the Task Force on Science Policy.

Mr. Lujan.

Mr. LUJAN. Thank you, Mr. Chairman.

I don't have an opening statement. I am pleased to be here this morning to listen to those who were responsible for putting out this excellent report. I do think it's excellent, and I look forward to hearing from all of you. Thank you, Mr. Chairman.

Mr. BROWN. Thank you, Mr. Lujan.

Now, we will hear from the task force: Richard A. Zdanis, Ray C. Hunt. Mr. Zdanis is vice provost of Johns Hopkins. Mr. Hunt is vice president for business and finance at the University of Virginia, and Praveen Chaudari, vice president, science and director, Physical Sciences Department of the IBM Corp., accompanied by Mr. Milton Goldberg, executive director of the Council on Governmental Relations, and Ms. Suzanne Woolsey, partner, Coopers & Lybrand.

We are pleased to have you all here. You start first, Dr. Zdanis, I believe.

STATEMENT OF DR. RICHARD A. ZDANIS, VICE PROVOST, THE JOHNS HOPKINS UNIVERSITY, BALTIMORE, MD

Dr. ZDANIS. Thank you, Mr. Chairman.

I appreciate this opportunity to appear before you as chairman of the steering committee that directed the newly published report *Financing and Managing University Research Equipment*. My colleagues and I hope to outline for you the findings and recommendations of our study and, of course, we will be happy to answer questions.

As you have noted, the events which bring us here today began in the early 1970's when the problem of maintaining and replacing modern research equipment was noted in American universities, and these problems are now acknowledged to be severe. Let me quote a few statistics from the National Science Foundation's *National Survey of Academic Research Instruments.* The *Survey* covers the years 1982 and 1983, and it shows in part that 72 percent of the academic department heads surveyed said that there was lack of instruments which was preventing critical experiments. Twenty percent of the universities' inventories of scientific equipment were obsolete and are no longer useful for research purposes. Twenty-two percent of the instrument systems in use in research were more than 10 years old. Only 52 percent of the instruments in use were reported to be in excellent working condition. Forty-nine percent of the department heads surveyed said that the instrument-support services, such as machine electronic shops, were of poor quality or nonexistent.

I think you will agree that these conditions are not what the Nation must have. To some degree, this situation was created by scientific and technical progress. Rapid gains in the productivity and sensitivity of research instruments have been accompanied by the higher costs of buying and operating and maintaining these pieces of equipment. The cost of acquisition has outpaced inflation. The same progress that brought us greater capability of instruments has also shortened their useful lives. For 15 years, the funds from all sources for research equipment has not met the needs created by rising costs and more limited useful lives.

An Interagency Working Group on Research Instrumentation—composed of several officials of the National Science Foundation, the National Institutes of Health, the National Aeronautics and Space Administration, the Departments of Agriculture, Defense and Energy—was convened in the early 1980's to coordinate action on this problem.

The States, industry and universities themselves launched various initiatives. Of course, in times of limited budget in which we are pleased to live, it's of utmost importance that the maximum use be made of the funds available, and the Interagency Working Group approached the Association for American Universities, the National Association of State Universities and Land-Grant Colleges, and the Council on Governmental Regulations, and asked it to—asked them to undertake a special effort to identify any barriers which may prevent the most expeditious acquisition of equipment and to document new and innovative financing mechanisms which might exist for replacing and refurbishing the research equipment.

The three associations undertook the study that we are reporting on today, and it's important to note that funds for this study were contributed by the six Federal agencies represented on that Interagency Working Group as well as the research corporation. A steering group of scientists and administrators from the academic community and industry was established to direct the study, and onsite interviews were conducted at university and industrial laboratories as well as national laboratories and extensive interviews on reviews of legislation at both Federal and State levels. The report of the field research team by three experienced science administrators reflected meetings with more than 500 individuals at 23 university, developmental, and industrial laboratories. The firm of Coopers & Lybrand also did field work in addition to extensive literature review in its report on debt financing and tax aspects. These reports and other information developed by the three associations were combined into our final report. In general, we examined the Federal and State regulations, practices, and management practices within the universities, and the sources of funding mechanisms for instruments. We have 26 recommendations directed at each of these sectors. In addition, we reached the comprehensive conclusion, and that I will quote from the summary of our report:

> Many actions can be taken that clearly would enhance the efficiency in acquisition of, management, and use of research equipment by universities. . . . The overall problem is so large, however, that it can not be properly addressed without substantial, sustained investment by all sources—federal and state governments, universities, and the private sector.

Let me take a moment to emphasize "sustained investment." Because of the relatively short lifetime of adequate research equipment these days, it's important that an investment strategy be developed which will be sustained over time to address this problem and any solution must recognize this costly fact.

Let me turn to the role of the Federal Government. There are five topical sections in our report, and the Government, as the task force well knows, is the leading funder of academic research.

The potential impact of Federal regulations on efficiency in buying and managing equipment is correspondingly large. We looked at the Federal regulations and the two basic circulars which undergird the purchase of equipment, A-21 and A-110. In addition, there are the Federal acquisition regulations, and each of these circulations may be supplemented by agency regulations. Only certain parts of those circulars apply to scientific equipment.

We find few barriers that contribute to the problems directly within the language of the regulations; however, the difficulty is in interpretation and application of those regulations by the Federal agencies. Interpretations vary from agency to agency, from region to region within the country, within the same agencies, and from time period to time period. So that, in this swirl of uncertainty, university management is forced to be very conservative, and it's so conservative as to be inefficient at times, we believe.

So, therefore, we believe as a first step that the heads of the Federal agencies should issue internal policy statements designed to reinforce their commitment to the overall goal of assuring the efficient acquisition and maintenance of research equipment. Today we discuss global goals. What is the acquisition of research equipment throughout the Nation, throughout all of the Federal agencies? However, on a daily basis, the management is done on a program-by-program basis. The success, promotional performance and evaluation is on a program-by program basis. It's not clear that the sum of all those local optimizations of each program necessarily is the same as the global optimizations of the acquisition of research instrumentation across the Nation. It would help considerably to have statements that would encourage action at the programmatic level to adhere to global policies that we believe are proper for the Nation.

This we are going to talk about—commingling of funds and use of equipment by multiple projects, that is across agencies, across particular tasks, and those are decisions that are difficult for program administrators to take unless they have an overall guiding statement that, yes, this is part of the action that we believe is desirable for his agency by the agency head.

To be more specific, and addressing some other points of Federal barriers, the costs of a full functioning piece of research equipment are not always considered in an orderly manner. The full costs include space renovation, installation, service contracts, operation and maintenance, and technical support in addition to the initial purchase price. Federal agencies should consider the full costs of the equipment in research awards and insure they will be covered either by the research award itself or by the recipient as a condition of that award. In programs that require university contribution for matching funds toward acquisition of instruments, we believe that the agencies should accept payment of costs such as installation and maintenance as matching funds.

Individual research awards, the backbone of the Federal basic research support, usually are not large enough to accommodate equipment of more than modest cost. Investigators often will have more than one award but have difficulty combining funds from different awards to buy equipment. To ease this problem, we recommend that Federal agencies encourage the sharing of support for equipment across award and agency lines. We also recommend that they adopt procedures that make it easier to spread the cost of the equipment charged directly to research project awards over several award years.

Many universities are unable to recover costs of non-federally funded equipment used in conducting federally-sponsored research on a timely basis. This famous circular, A-21, permits universities to recover these costs through an annual use allowance of 6⅔ percent. At this rate, the full cost is not recovered for 15 years. Historically, that was not an unreasonable recovery rate because of the then useful life of this research equipment. However, today, state-of-the-art equipment may have a realistic life which is 5 years or less. Circular A-21 also permits universities to recover the cost of non-federally funded equipment by depreciating it over a realistic lifetime, and it permits them to change from the use allowance to the depreciation formula. However, when universities make the switch, auditors of the Department of Health and Human Services have permitted recovery as if the equipment has always been depreciated. For example, if a piece of equipment purchased with university funds had a useful life of 5 years and was 3 years old when the switch in accounting procedures took place, 20 percent of the cost would have been recovered under use allowance; 40 percent would be recovered under depreciation in future years. However, the university would never recover 40 percent of the cost simply because it had changed accounting procedures. This practice is a major disincentive to universities to invest their own funds in research equipment which will be used on federally-sponsored research.

Less troublesome is the uncertainty surrounding recovery of interest on money that universities borrow externally to finance equipment. Circular A-21 states that interest is an allowable charge to Federal awards at the discretion of the funding agency.

Approval is required for each purchase, and there are instances when even before the fact, agency acceptance in principle has been obtained. When specific purchases have been asked to allow the charge to be put into the indirect cost pool, the approval has been denied. We believe that universities should not be subject to this flexibility of this decisionmaking, and OMB should revise this circular to make it an allowable charge.

Policies regarding title to equipment vary among agencies. Those who wish to combine university funds with Federal funds to buy an instrument are uncertain about where the title will reside. It's especially true where research is funded by contracts rather than grants, and we recommend that all Federal agencies invest title to equipment in the universities upon acquisition.

The management of research equipment is also complicated by a number of paper working rules that are embodied in Circulars A-21 and A-110. The thresholds at which documentation needs to be retained are unrealistically low, and they are inconsistent between these two circulars. We recommend that they be raised to a realistic level, and that will prevent the abuses that might occur in multiple purchases of equipment. That may occur, but it will reduce the paperwork considerably.

Circular A-110, for instance, requires that the university inventory be researched to prevent duplicative purchases at a $300 threshold—an unrealisticly low point. We recommend the screening levels be raised considerably. The screening levels have been negotiated at a $10,000 level, but on a university-by-university basis. This is again one of the uncertainties of dealing with the multitude of agencies and actors within agencies where one university may be allowed to keep an inventory and do the screening at a $10,000 level when a neighbor or good institution is not given that privelege.

We recommend that the Department of Defense discontinue its requirement that the inventory of the Defense Industrial Plant Equipment Center be screened for scientific equipment which is requested by universitites before new equipment is purchased. We found, in the course of our study, no piece of equipment that could be identified which was acquired via this screening.

The last of our recommendations in the Federal area involves the prior agency approvals for various actions under research grants and contracts. These requirements can significantly delay equipment transactions. Certain prior approval authorities are delegated to universities under the Institutional Prior Approval System of the NIH and the Organizational Prior Approval System of NSF. These two systems, among other benefits, reduce the turnaround time on requests from weeks to days, and the savings can permit the university to take advantage of timely purchase price discounts and other special arrangements. We recommend that these systems which have proved themselves in the field be adopted by other Federal agencies.

Thank you for this opportunity to present this material, and I would now like to turn to Ray Hunt.

[The prepared statement of Dr. Zdanis follows:]

Mr. Chairman and members of the Task Force on Science Policy:

My name is Richard Zdanis, and I am Vice Provost of the Johns Hopkins University. I appreciate this opportunity to appear before you as chairman of the steering committee that directed the newly published study "Financing and Managing University Research Equipment." My colleagues and I will outline for you the findings and recommendations of our study and will be happy to answer questions. A summary of the study is attached to my written testimony. We understand that the National Science Foundation has distributed the full report to the Committee.

With me today are two other members of our steering committee, Praveen Chaudhari of IBM and Ray Hunt of the University of Virginia. Also with me are Milton Goldberg of the Council on Governmental Relations. Suzanne Woolsey of Coopers & Lybrand, Patricia Warren, Project Manager, and John Crowley, Director of Federal Relations for Science Research of the Association of American Universities. The Council with the Association of American Universities and the National Association of State Universities and Land-Grant Colleges were the organizers of our study, and Coopers & Lybrand helped us with the debt-financing and tax-related aspects.

The events that bring us here began in the early 1970s, when U.S. universities began to experience problems maintaining and replacing modern research equipment. These problems are now widely acknowledged as extremely severe. The situation threatens the quality of our academic science as well as the quality of education of new scientists and engineers. Let me cite just a few statistics from the National Science Foundation's National Survey of Academic Research Instruments. The survey covers the years 1982 and 1983. It shows in part that:

- 72% of academic department heads surveyed said that lack of equipment was preventing critical experiments.
- 20% of universities' inventories of scientific equipment was obsolete and is no longer useful for research.
- 22% of instrument systems in use in research were more than 10 years old.
- Only 52% of instruments in use were reported to be in excellent working condition.
- 49% of department heads surveyed said that instrument-support services--such as machine and electronics shops--were of poor quality or nonexistent.

I think you will agree that the condition of research instrumentation available to universities is not what we must have. To some degree, this situation was created by scientific and technical progress. The rapid gains in the productivity and sensitivity of research instruments has been accompanied by higher costs for buying, operating, and maintaining them. The costs of acquisition have well outpaced inflation. The same progress that has brought greater capability to instruments has also shortened their useful lives. Instruments today may be superseded by better ones in five years of less. Finally, for more than 15 years, funds from all sources for research equipment have not met the needs created by rising costs and shrinking useful lifetimes.

Major efforts to ease the universities' difficulties with research equipment began in the early 1980s. An Interagency Working Group on research instrumentation--composed of several officials of the National Science Foundation, the National Institutes of Health, the National Aeronautics and Space Administration, and the Departments of Agriculture, Defense, and Energy--was convened to coordinate action on this problem. The states, industry, and the universities themselves also launched various initiatives. These developments have helped, but the equipment problem has by no means been solved.

Federal and academic officials, of course, were well aware that with limited budgets available it was of utmost importance that these funds be used as efficiently as possible. In July 1982, the Interagency Working Group asked the Association of American Universities, the National Association of State Universities and Land-Grant Colleges, and the Council on Governmental Relations to undertake a special effort to identify any barriers that may prevent the most expeditious acquisition of equipment and to document new and effective financing and management techniques for academic research equipment.

The three associations jointly undertook the study we're reporting on today. Funds for the study were provided by the six federal agencies represented on the Interagency Working Group as well as the Research Corporation. A Steering Committee composed of scientists and administrators from both the academic community and industry was established to direct the study. On site interviews were conducted at university and industrial laboratories as well as extensive reviews of legislation and regulation at both the federal and state levels. The report prepared by a field research team of three experienced science administrators reflected meetings with more than 500 individuals and 23 university, governmental and industrial laboratories. The firm of Coopers and Lybrand also did field work in addition to an extensive literature review for its report on debt financing and tax aspects. These reports and other information developed by the three associations were combined in our final report.

In general, we examined federal and state regulations and practices, management practices in universities, and sources and mechanisms of funding. We have 26 recommendations directed to the federal and state governments, the universities, and the private sector. In addition, we also reached one comprehensive conclusion, and I will quote it from the summary of our report:

> Many actions can be taken that clearly would enhance efficiency in the acquisition, management, and use of research equipment by universities...The overall problem is so large, however, that it cannot be properly addressed without substantial, sustained investment by all sources--federal and state governments, universities, and the private sector.

I would like to emphasize the words "sustained investment." Laboratories in most sciences must now be reequipped approximately every five years to remain competitive in research. Any effective approach to maintenance of a competitive research environment must recognize this costly fact.

Let me now turn to the role of the federal government, the first of the five topical sections of our study. The government, as the Task Force well knows, is the leading funder of academic research. Federal agencies account for nearly two-thirds of the funds spent annually to buy academic research equipment. The potential impact of federal regulations on efficiency in buying and managing equipment is correspondingly large.

The basic federal regulations that we assessed are Office of Management and Budget Circulars A-21 and A-110 and the Federal Acquisition Regulations. Circulars A-21 and A-110 apply to research grants, and Circular A-21 and the FAR apply to research contracts. These regulations may be supplemented by agency rules. Only certain parts of them apply to scientific equipment.

We find that few of the basic federal regulations contribute directly to problems with equipment. The difficulties arise mainly from the interpretation and application of the regulations by federal agencies. Interpretations vary from agency to agency from region to region, and from time period to time period. This inconsistency leads universities to adopt unnecessarily conservative management practices, which further complicate equipment problems. We think changes can be made that would much improve efficiency in dealing with equipment without going against the purpose of the regulations--insuring accountability for public funds.

As a first step, we recommend that the heads of federal agencies that support academic research issue internal policy statements designed to reinforce their commitment to the overall goal of assuring the efficient acquisition and management of research equipment. Today we are discussing global goals for the nation and universities, but on a daily basis decisions are made at the project level and performance appraisal is conducted on a by-program basis. Some of the recommendations we make advocate the comingling of funds and the use of equipment by multiple projects. Agency statements that these actions are to be encouraged would be a major help in providing guidance at the program level. We also recommend actions aimed at certain specific barriers.

One of these barriers is that federal agencies--and states and universities as well--do not provide for the full costs of functioning research equipment in an orderly manner. These full costs may include space renovation, installation, service contracts, operation and maintenance, and technical support in addition to initial purchase price. Federal agencies should consider the full costs of equipment in research awards and insure that they will be covered either by the research award itself or by the recipient as a condition of the award. In programs that require the university to contribute matching funds toward the acquisition of instruments, the agencies should accept universities' payment of costs such as installation and maintenance as matching funds.

Individual research-project awards, the backbone of federal support for basic research, usually are not large enough to accommodate equipment of more than modest cost. Investigators often will have more than one award, but they have difficulty combining funds from different awards to buy equipment. To ease this problem we recommend that federal agencies encourage the sharing of support for equipment across award and agency lines. We also recommend that they adopt procedures that make it easier to spread the cost of equipment charged directly to research-project awards over several award years.

Many universities are unable to recover the cost of nonfederally funded equipment used in conducting federal sponsored research, on a timely basis. OMB Circular A-21 permits universities to recover these costs through an annual use allowance of 6 2/3 percent of acquisition cost. At this rate, full cost isn't recovered for at least 15 years. Historically, this was not an unreasonable recovery rate but today the realistic life of state-of-the-art equipment may be five years or less. Circular A-21 also permits universities to recover the cost of nonfederally funded equipment by depreciating it over a realistic lifetime, and it permits them to change from use allowance to depreciation. But when universities make the switch, auditors of the Department of Health and Human Services only permit recovery as if the equipment had been depreciated. For example, if a piece of equipment purchased with university funds had a useful life of 5 years, and was 3 years old when the switch in accounting took place 20% of the cost of the equipment would have been recovered under use allowance. 40% will be recovered under depreciation in future years. The university will never recover 40% of the cost simply because it changed accounting procedures. This practice is a major disincentive to universities own investments in research equipment used for federally sponsored research. We have recommended that this practice be changed to permit full recovery.

Also troublesome is the uncertainty surrounding recovery of interest on money that universities borrow externally to finance equipment. Circular A-21 states that the interest is an allowable charge to federal awards, at the discretion of the funding agency. Approval is required for each purchase and even when agencies have approved the concept in principle interest may not be allowed on specific purchases. We believe OMB should revise Circular A-21 to make such interest unequivocally an allowable cost. University officials who are uncertain about recovering interest are reluctant to consider debt financing as a mechanism for updating equipment.

Policies regarding title to equipment vary among agencies. Investigators or administrators may wish to combine university funds with federal funds to buy an instrument, but without assurance of title they may be unable to do so. This is especially true where research is funded by contracts rather than grants. We recommend that all federal agencies vest title to equipment in the university upon acquisition.

Management of research equipment by universities is complicated by certain provisions of OMB Circulars A-21 and A-110. The Circulars prescribe capitalization thresholds that are unrealistically low and also different--$500 in A-21 and $300 in A-110. Universities must maintain equipment inventories, and these would be simpler to manage if the capitalization thresholds were raised and made uniform. We recommend a threshold of $1000--this level would likely halve the number of items in the typical university inventory of capital equipment while retaining 80% o the combined value.

Circular A-110 requires universities to avoid buying duplicate equipment, which is interpreted to mean that they must screen their inventories before purchase. We learned that the $300 threshold requires a great deal of screening for equipment that isn't economical to share. Higher screening levels have been negotiated, and we recommend that OMB set the minimum at $10,000. At one university we visited, that level accounted for 3.2% of the pieces of equipment in the inventory bought in 1983 and 50% of the dollar value.

We also recommend that the Department of Defense discontinue its requirement that the inventory of the Defense Industrial Plant Equipment Center (DIPEC) be screened for scientific equipment requested by universities before new equipment is purchased. We found no one in the course of our study who could identify any research equipment acquired via DIPEC screening.

The last or our recommendations on federal regulations involves the prior agency approvals required for various actions under research grants and contracts. These requirements can significantly delay equipment transactions. Certain prior-approval authorities are delegated to universities under the Institutional Prior Approval System (IPAS) of NIH and the Organizational Prior Approval System (OPAS) of NSF. IPAS and OPAS, among other benefits, reduce turnaround time on requests from weeks to days. The saving can permit the university to take advantage of timely price discounts or other special arrangements. We recommend that these systems be adopted by other federal agencies.

Again, I appreciate the opportunity to appear before you today on this important matter. You will hear next from Ray Hunt of our steering committee.

Mr. BROWN. Dr. Hunt.

STATEMENT OF DR. RAY C. HUNT, JR., VICE PRESIDENT FOR BUSINESS AND FINANCE, UNIVERSITY OF VIRGINIA, CHARLOTTESVILLE, VA

Dr. HUNT. Mr. Chairman, members of the task force, today I will briefly give you the ideas that we have developed during the research instrumentation project on the roles of States and universities relative to scientific equipment. I will also touch briefly on the subject of debt financing.

The NSF study mentioned earlier found that States directly funded 5 percent of the aggregate cost of instruments in use in the academe in 1982 and 1983. States also pay for equipment indirectly through tax benefits. On the other hand, the States often hamper the purchase and use of equipment through regulations and restrictions on schools' financial flexibility. These activities apply mainly to public universities. Private institutions rarely have access to State funds, and they are virtually exempt from State controls on equipment, except when they use State borrowing authority.

The States' broad roles as funder and regulator of scientific equipment in public universities are inherently in conflict to some degrees. Nevertheless, we think they could combine these roles more rationally in ways that would help the schools with their equipment problems.

The States are not going to replace the Federal Government as the major funder of academic research equipment. But we do think they should look carefully at their direct support for scientific equipment in both the public and private institutions, relative to support from other sources. Judicious and highly selective increases in State funding could be most helpful to the scientific stature of the States and could also make Federal and industrial funds more effective.

We also recommend that States give their universities more latitude in handling funds. We think that institutions should be permitted such actions as transferring funds among budget categories and carrying funds forward from one fiscal period to the next. A fiscal period typcially is 1 or 2 years. The added flexibility would clearly make the universities better able to deal with problems of research equipment. We also think greater flexibility would save money in the purchasing process and permit academic administrators to do their jobs more effectively.

Tax benefits specified in the Economic Recovery Tax Act of 1981 are available to equipment donors in 34 States simply because their tax codes follow the Federal code. Relatively few States have adopted tax benefits designed to fit their particular circumstances. We think the States should examine the use of their taxing powers to foster both academic research and modernization of the equipment it requires.

State procurement controls also need attention. In general, we think they should be revised to suit the unusual nature of scientific equipment. Such equipment should be exempt from purchasing requirements designed for generic items like batteries and cleaning materials, where brand-to-brand differences may be insignificant.

Each university should have the authority to buy scientific equipment without having rules imposed beyond those of Federal agencies.

We recommend that States consider revising their controls on debt financing so as to help public universities acquire scientific equipment. It would be helpful if debt financing could be used to buy equipment independently of construction projects, which now is not generally the case. It would also be helpful to recognize that scientific equipment may need to be replaced in only a few years, although acquired as part of a construction project financed for 30 years.

Finally, we think that schools ought to be permitted to lease research equipment for periods longer than the 1- or 2-year state budget period to which they are now often held. This restriction limits the institutions' ability to arrange advantageous leases.

The universities themselves, public and private, funded about one-third of major instrumentation systems in use in 1982 to 1983, according to NSF. The schools deal with scientific equipment in many ways in addition to the conduct of research. They fund equipment from their own resources, from gifts they solicit, and from various forms of debt financing; they handle the purchasing process; they pay part or all of the costs of operation and repair; they maintain equipment inventories; they help to optimize the sharing of equipment by investigators; and they handle disposal of equipment no longer needed or useful.

Given this degree of involvement, one would expect to find opportunities to improve efficiency, and we did. The measures we believe would help suggest that universities individually ought to consider a more centralized approach than is now common in their acquisition and management of research equipment. I might point out that other pressures also appear to be pushing the schools toward a more centralized approach in their operations in general. These pressures include the growing interest in debt financing and joint development efforts with State governments and industry.

We concluded that universities should plan their allocation of resources more systematically to favor research and research equipment in subject areas that offer them the best opportunities to achieve distinction. In other words, we recommend that universities engage in more intense strategic planning with participation by both administrators and faculty. Hard decisions may be required as a result of conscious strategic planning, but we think they are needed to optimize the use of funds available.

We also recommend that universities budget more realistically for the costs of operating and maintaining research equipment. As you heard earlier, we think that Federal agencies can help to encourage realistic budgeting through practices associated with their research-award procedures. Lack of operating and maintenance costs are serious and pervasive problems at universities, and lack of planning for the full costs of research equipment is much too common. User charges are often assessed to cover maintenance and the costs to support staff, but they can rarely be set at a high enough level to recover full costs.

You also heard earlier that individual research awards cannot usually accommodate costly equipment. We believe that Federal agencies should make it easier to spread the costs of equipment charged directly to awards over several award years. We also recommend that university administrators and investigators more aggressively seek agency approval to do so.

Universities could facilitate timely acquisition of research equipment at optimum cost by working to minimize delays and other problems caused by procurement procedures. The purchasing process, as I said earlier in regard to the role of the States, ought to be adapted to the specialized nature of the research equipment. Specialized purchasing entities or individuals can help. We also recommend formal programs to explain to purchasing personnel and investigators the needs and problems of each.

We believe that universities should also consider establishing inventory systems that facilitate sharing of equipment by investigators. The inventory systems encountered by our field research team were not generally useful for this purpose, with one exception—the inventory set up by the Research Equipment Assistance Program [REAP] at Iowa State University. The REAP inventory contains only research equipment. The program may not be cost-effective for all universities, but we think that most of them would find parts of it useful.

Another point touched on earlier is the choice of use allowance or depreciation to generate funds for replacing equipment. We recommend that depreciation be used because the funds in principle can be generated over the useful life rather than the unrealistic 15 years required by the use allowance. This recommendation presumes that universities can negotiate realistic depreciation schedules and dedicate the funds to purchase of equipment. You will recall that costs can be recovered by use allowance or depreciation only for non-federally funded equipment. I should also add that both methods add to the indirect costs, which are always under pressure to be reduced and are particularly contentious between academic administrators and investigators.

We also recommend that universities look for better and more systematic ways to facilitate internal transfer of equipment from investigators and laboratories that no longer need it to those that could use it. Faculty at most schools have no incentive to transfer equipment, except for the need for space, and every incentive to hang on to it, just in case there is a future need.

Universities, as you know, have long used tax-exempt debt to pay for major facilities. In more recent time they have been using this method to some extent to buy research equipment. We believe they should explore greater use of tax-exempt debt for this purpose, so long as proper attention is given to the long-term consequences of debt. A basic requirement when assuming debt is a reliable stream of income to pay it off. This commitment of funds cuts into the university's flexibility in responding to new and unanticipated opportunities. Also, debt financing obviously increases the overall cost of scientific equipment to both the universities and the external sponsors of research.

We recommend that universities develop their own expertise on leasing and debt financing. Outside counsel will still be needed to issue major debt, but institutions should be able to determine the true costs of debt financing and make this expertise and related information readily accessible to research administrators and to principal investigators. The increasing complexity and variety of debt financing procedures and instruments—for any purpose—make it essential that universities fully understand the marketplace.

I wish to thank you for your attention. The third member of our steering committee here today is Praveen Chaudhari who will conclude our presentation on the research instrumentation project.

[The prepared statement of Dr. Hunt follows:]

Mr. Chairman and members of the Task Force:

I am Ray Hunt, and I am Vice President for Business and Finance at the University of Virginia. Today I will briefly give you the ideas we developed during the research instrumentation project on the roles of states and universities relative to scientific equipment. I will also touch on debt financing of equipment.

The NSF study mentioned earlier found that the states directly funded 5% of the aggregate cost of instruments in use in academe in 1982-83. States also pay for equipment indirectly through tax benefits. On the other hand, the states often hamper the purchase and use of equipment through regulations and restrictions on schools' financial flexibility. These activities apply mainly to public universities. Private institutions rarely have access to state funds, and they are virtually exempt from state controls on equipment, except when they use state borrowing authority.

The states' broad roles as funder and regulator of scientific equipment in public universities are inherently in conflict to some degree. Nevertheless, we think they could combine these roles more rationally in ways that would help the schools with their equipment problems.

The states are not going to replace the federal government as the major funder of academic research equipment. But we think they should look carefully at their direct support for scientific equipment in both public and private institutions, relative to support from other sources. Judicious and highly selective increases in state funding could be most helpful to the scientific stature of the states and could also make federal and industrial funds more effective.

We also recommend that states give their universities more latitude in handling funds. We think that institutions should be permitted such actions as transferring funds among budget categories and carrying funds forward from one fiscal period to the next. A fiscal period typically is one or two years. The added flexibility would clearly make the universities better able to deal with problems of research equipment. We also think greater flexibility would save money in the purchasing process and permit academic administrators to do their jobs more efficiently.

Tax benefits specified in the Economic Recovery Tax Act of 1981 are available to equipment donors in 34 states whose tax codes automatically follow the federal code. Relatively few states have adopted tax benefits designed to fit their particular circumstances. We think the states should examine the use of their taxing powers to foster both academic research and modernization of the equipment it requires.

State procurement controls also need attention. In general, we think they should be revised to suit the unusual nature of scientific equipment. Such equipment should be exempt from purchasing requirements designed for generic items like batteries and cleaning materials, where brand-to-brand differences may be insignificant. Each university should have the authority to buy scientific equipment without having rules imposed beyond those of federal agencies that fund equipment.

We recommend that states consider revising their controls on debt financing so as to help public universities acquire scientific equipment. It would be helpful if debt financing could be used to buy equipment independently of construction projects, which now is not generally the case. It would also be helpful to recognize that scientific equipment may need to be replaced in only a few years, although acquired as part of a construction project financed by 30-year debt. Finally, we think that schools ought to be permitted to lease research equipment for periods longer than the one- or two-year state budget period to which they are now often held. This restriction limits the institutions' ability to arrange advantageous leases.

The universities themselves, public and private, funded about one-third of major instrumentation systems in use in 1982-83, according to NSF. The schools deal with scientific equipment in many ways in addition to the conduct of research. They fund equipment from their own resources, from gifts they solicit, and from various forms of debt financing; they handle the purchasing process; they pay part or all of the costs of operation and repair; they maintain equipment inventories; they help to optimize the sharing of equipment by investigators; and they handle disposal of equipment no longer needed or useful.

Given this degree of involvement, one would expect to find opportunities to improve efficiency, and we did. The measures we believe would help suggest that universities individually ought to consider a more centralized approach than is now common in their acquisition and management of research equipment. I might point out that other pressures also appear to be pushing the schools toward a more centralized approach in their operations in general. These pressures include the growing interest in debt financing and joint development efforts with state governments and industry.

We concluded that universities should plan their allocation of resources more systematically to favor research and research equipment in subject areas that offer them the best opportunities to achieve distinction. In other words, we recommend that universities engage in more intense strategic planning, with participation by both administrators and faculty. Hard decisions may be required as a result of conscious strategic planning, but we think they are needed to optimize the use of the funds available.

We also recommend that universities budget more realistically for the costs of operating and maintaining research equipment. As you heard earlier, we think that federal agencies can help to encourage realistic budgeting through practices associated with their research-award procedures. Lack of operating and maintenance costs are serious and pervasive problems at universities, and lack of planning for the full costs of research equipment is much too common. User charges are often assessed to cover maintenance and the costs of support staff, but they can rarely be set high enough to recover full costs.

You also heard earlier that individual research awards cannot usually accommodate costly equipment. While we believe that federal agencies should make it easier to spread the costs of equipment charged directly to awards over several award years, we also recommend that university administrators and investigators more aggressively seek agency approval to do so.

Universities could facilitate timely acquisition of research equipment at optimum cost by working to minimize delays and other problems caused by procurement procedures. The purchasing process, as I said earlier in regard to the role of the states, ought to be adapted to the specialized nature of the equipment. Specialized purchasing entities or individuals can help. We also recommend formal programs to explain to purchasing personnel and investigators the needs and problems of each.

We believe that universities also should consider establishing inventory systems that facilitate sharing of equipment by investigators. The inventory systems encountered by our field-research team were not generally useful for this purpose, with one exception--the inventory set up by the research equipment assistance program (REAP) at Iowa State University. The REAP inventory contains only research equipment. The program may not be cost-effective for all universities, but we think that most of them would find parts of it useful.

Another point touched on earlier is the choice of use allowance or depreciation to generate funds for replacing equipment. We recommend depreciation because the funds in principle can be generated over the useful life rather than the unrealistic 15 years required by the use allowance. This recommendation presumes that the university can negotiate realistic depreciation schedules and dedicate the funds to equipment. You will recall that costs can be recovered by use allowance or depreciation only for nonfederally funded equipment. I should add that both methods add to indirect costs, which are always under pressure to be reduced and are particularly contentious between academic administrators and investigators.

We also recommend that universities look for better and more systematic ways to facilitate internal transfer of equipment from investigators and laboratories that no longer need it to those that could use it. Faculty at most schools now have no incentive to transfer equipment, except the need for space, and every incentive to hang on to it, just in case.

Universities, as you know, have long used tax-exempt debt to pay for major facilities. Lately, they have been using this method to some extent to buy research equipment. We believe they should explore greater use of tax-exempt debt for this purpose, so long as proper attention is given to the long-term consequences. A basic requirement when assuming debt is a reliable stream of income to pay it off. This commitment of funds cuts into the university's flexibility in responding to new and unanticipated opportunities. Also, debt financing obviously increases the overall cost of scientific equipment to both the universities and the external sponsors of research.

We recommend that universities develop their own expertise on leasing and debt financing equipment. Outside counsel will still be needed to issue major debt, but institutions should be able to determine the true costs of debt financing and make this expertise and related information readily accessible to research administrators and principal investigators. The increasing complexity and variety of debt financing procedures and instruments--for any purpose--make it essential that universities fully understand the marketplace.

Thank you for your attention. The third member of our steering committee here today is Praveen Chaudhari, who will conclude our presentation on the research instrumentation project.

Mr. **Brown**. Dr. Chaudhari, could we ask you to bear with us for a few moments while we go over and answer that rollcall, and then we will come back and continue.

We will recess briefly, and I urge all the members to return promptly.

[Recess.]

Mr. **Brown**. The task force will resume.

We will call on Dr. Chaudhari to proceed with his portion of the statement.

STATEMENT OF DR. PRAVEEN CHAUDHARI, VICE PRESIDENT, SCIENCE, AND DIRECTOR, PHYSICAL SCIENCES DEPARTMENT, IBM CORP., ARMONK, NY

Dr. **Chaudhari**. Mr. Chairman and members of the task force, my topic is private support for academic research. Private support for higher education, as the data compiled by the Council for Financial Aid to Education show, has more than tripled from 1966 through 1983 to $5.15 billion. Corporate support has been rising faster than other private funding and in 1983 comprised 21.4 percent of the total. It is more than twice as likely to be earmarked for research as are contributions from other private sources. However, corporate sources accounted for only 4 percent of the total dollar value of academic equipment in 1982–1983. In comparison, the National Science Foundation's survey of equipment in use in 1982–1983 shows Federal funding accounts for 54 percent, university funding for 32 percent, State governments and other private support for 5 percent each, of the total of approximately $1.18 billion.

How can we increase private support for academic equipment? Before answering this question and making a set of recommendations, I should like to describe to you what we have learned from our own survey about the reasons cited for corporate support of equipment, the limitations on such support, and how support is provided.

Equipment is provided to universities by corporations on a charitable or discounted basis for several reasons: to help sustain the quality of teaching and of research; to expose prospective customers to their products; to get feedback on the performance of their products and on need for new equipment; and to maintain good relations with faculty.

Universities are a major market for scientific equipment. They are also a major source of research results needed by designers and makers of such equipment. These companies clearly have an interest in the academic world, but they also have an inherent conflict between charitable contributions and profit making.

Donations of equipment usually do not cover the costs of renovating space and installing, operating, and maintaining the instrument donated. These expenses can be a significant part of research.

Universities acquire equipment from companies in many ways. These include cash gifts, contract research, discounts on equipment sales, industrial affiliate programs, research consortia, informal loans and sharing of equipment, and, of course, outright purchase. Donations of equipment in recent years have been especially common in computing, microelectronics, and engineering. Companies often use discounts and flexible payment schedules to help universities get research equipment. One manufacturer visited by the field research team used a two-for-one discount on purchase of new equipment to generate goodwill and to start a series of informal exchanges between its scientists and investigators at the recipient school.

We found that the tax benefits have several possible effects. The tax situation seems to influence the size of contributions. Also, a manufacturer may elect to sell costly equipment to a university at a substantial discount rather than donating it outright. Companies have taken this tack both before and after the Economic Recovery Tax Act, ERTA, of 1981, but the added tax benefits under the act clearly could affect the decision to sell or donate. In fact, a company that wishes to help a university get qualified research equipment but doesn't wish to donate it outright can still get tax benefits under ERTA by means of a bargain sale—a sale for less than fair market value.

The Economic Recovery Tax Act of 1981, as the task force knows, was designed to spur technological development. The act provides special charitable deductions for scientific equipment given to a university by its manufacturer. It also provides tax credits for company spending on research and development conducted inhouse or by universities or other organizations. The R&D tax credit is scheduled to expire at the end of this year.

As you have heard, 34 States whose tax codes follow the Federal code have adopted the provisions of ERTA. Also, as of the completion of our study, 7 States, including some of the 34, had adopted various additional tax benefits designed to encourage support for research and research equipment at universities.

It may not be possible to assess the impact of ERTA very accurately, in terms of either the R&D tax credit or equipment donations. As you know, the results of extensive study presented during hearings on the act in 1984 provided conflicting evidence of its impact. Nevertheless, the consensus seems to be that ERTA, especially with certain modifications, should spur technological progress as intended, partly by encouraging private support for academic research and scientific equipment. We agree with this view.

Let me return now to the question of how can we increase private support for academic research and for equipment in particular. We recommend that universities seek donations of research equipment more aggressively. Although our full report gives the elements of a donation strategy in some detail, let me stress a particular point here. We believe that personal involvement of academic researchers with their counterparts in likely donor companies is essential to cultivating the relationships needed to get contributions of research equipment. Quite apart from donation of equipment, such interactions are desirable for exchange of technical information which, in turn, enhances technological progress.

We recommend several modifications to ERTA.

First, we propose that the range of equipment qualified for the charitable donation deduction be expanded to include computer software, equipment maintenance contracts and spare parts, equipment in which parts not made by the donor cost more than 50 percent of the donor's cost in the equipment, and used equipment less than 3 years old. Our arguments for these changes are as follows. Computers are incomplete without software. Maintenance contracts are valuable because keeping equipment in repair costs so much that universities have sometimes declined donations because of the maintenance expense. Companies that develop and make scientific equipment are selling primarily their technological knowledge, not their ability to make parts. For this reason, we believe the 50 percent limit on parts not made by the donor is unrealistic.

Next, we propose that the R&D tax credit be made permanent. We also recommend that the credit be revised to create a special incentive for companies to support research in universities. As it stands, ERTA gives companies the same incentive to contract for research in academe as in other qualified organizations.

We propose further that the social and behavioral sciences be made qualified fields of academic research in terms of both the equipment donation deduction and the R&D tax credit. These sciences contribute to the applications of other sciences and technology, and social and behavioral scientists are increasingly using instruments in their research.

Our last proposal for ERTA is that research foundations that are affiliated with universities, but remain separate entities, be made qualified recipients of equipment donations and R&D funding.

That, Mr. Chairman, concludes our presentation and the results of the research instrumentation project.

On behalf of my colleagues, I should like to thank you once again for your attention.

[The prepared statement of Dr. Chaudhari follows:]

Mr. Chairman and gentlemen:

I am Praveen Chaudhari, and I am Vice President for Science in the Research Division of IBM. My topic is private support for academic research equipment.

Private support for higher education, as the data compiled by the Council for Financial Aid to Education show, has more than tripled from 1966 through 1983 to $5.15 billion. Corporate support has been rising faster than other private funding and in 1983 comprised 21.4 per cent of the total. It is more than twice as likely to be earmarked for research as are contributions from other private sources. However, corporate sources accounted for only 4 per cent of the total dollar value of academic equipment in 1982-1983. In comparison, the National Science Foundation's survey of equipment in use in 1982-1983 shows federal funding accounts for 54 per cent, university funding for 32 per cent, state governments and other private support for 5 per cent each, of the total of approximately $1.18 billion.

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Our last proposal for ERTA is that research foundations that are affiliated with universities, but remain separate entities, be made qualified recipients of equipment donations and R&D funding.

That concludes our presentation of the results of the research instrumentation project. On behalf of my colleagues, I would like to thank you once again for your attention.

PANEL DISCUSSION

Mr. **Brown**. Do we have statements from Mr. Goldberg and Ms. Woolsey?

Mr. **Goldberg**. There is none from us, no.

Mr. **Brown**. Or are you here to correct the mistakes of the others?

Ms. **Woolsey**. No, thank you, Mr. Chairman.

Mr. **Brown**. Mr. Lujan, do you have any questions?

Mr. **Lujan**. Thank you, Mr. Chairman.

Two things occur to me as I listen to the testimony. One is to give the university more power in making determinations. We face that in the case of the problem we have in South Africa and Nicaragua and in El Salvador—the sharing of power. That is a very difficult thing to have somebody do, and I didn't realize we had that problem at the universities as well.

The other conclusion that—at least the thought they have—is that all of the testimony and the report talk about ways of the universities getting the money to buy the equipment, but it seems like the study did not include the university responsibilities. I guess it's just assumed that they will use the equipment intelligently if given to them.

Did that part come up at all in your deliberations? I don't find it in the report in any event.

Dr. **Zdanis**. Certainly the backbone of the research support program for the country has been the individual research project which undergoes peer review, and we certainly have encouraged the maintenance of that as the primary research funding mechanism, and under peer review we assume that the best projects will, in fact, continue to be funded, and the poorer projects will not be.

Mr. **Lujan**. Peer review—just changing the subject a little bit—has come under quite a little bit of discussion in the Science Policy Task Force. It's the result of 10 or 20 universities getting all of the money. Is that the same for instrumentation? Are the same 10 or 20 universities that get the top grant dollars also getting the top moneys in equipment?

Dr. **Zdanis**. Well, I would dispute the 10 or 20 institutions slightly. The number of institutions that share in university research dollars as supplied by the National Science Foundation, that set of numbers, that certainly has institutions in the hundreds that are sharing in the percentage.

Mr. **Lujan**. But percentagewise, what is it? Something like 75 percent or something?

Mr. **Brown**. I should interrupt the gentlemen to indicate to Dr. Zdanis that some members of the task force are a little biased because of the small States that they come from, as you know.

Mr. **Lujan**. Or because of the large States they come from.

Have tax credits—before that, let me ask this. You mentioned the Iowa State University REAP Program which is a good example of how things should be managed. Why don't the others do that if that is a good way of doing it?

Dr. **Hunt**. I mentioned that, Mr. Lujan, I think the inventory systems—most schools do have inventory systems and are required to have them. What we found is that they have not been using those systems other than for recordkeeping. They have not been using them as a management tool, and with the exception, I think, of the—where we found in the REAP case where a system was being used as a management tool for effective transfer of equipment from one lab to another and to avoid duplication of equipment. There is a good screening policy there.

Our recommendation is that institutions ought to make better use of inventory systems and using REAP programs as an example.

Mr. LUJAN. Certainly sounds good.

What effect has the tax credit for private sector entities had on giving to universities of both equipment and research credits? Has it been good and substantial or what?

Dr. CHAUDHARI. Our survey found almost unanimously in a sense that the Tax Act encouraged people to donate, but when corporations look to give equipment or donate equipment, they look at it first from their own point of view, what it means to them, and after they determine that, at that point they look at the donation and tax benefit that accrues from that to decide how much to give and whether to give it as a bargain sale or donate it outright. So, I think it plays a substantial role once the decision has been made to go ahead and donate equipment.

Mr. LUJAN. I think you are absolutely correct. One of the things I ran into while I was at home is a large company making a substantial donation of equipment to one of our universities. And I gathered that if they gave this big piece of equipment, then their system would be the primary one in the university—rather than the whole tax credit question. That is just a little icing on the cake.

Dr. CHAUDHARI. Yes, that has been our experience, yes.

Mr. LUJAN. One other question. What about joint use, like the computer centers that we are establishing? Do you find that an effective way of equipment utilization? Give me your thoughts on that.

Dr. CHAUDHARI. It's a little early to assess the supercomputer centers. It's been our experience—I say "ours," I mean IBM's experience—with the Cornell Center where we made donations of equipment and are working with them. We have people assigned there.

In fact, it's our intent to see how much we can use within IBM that center for our own work, so we are interested in that center for a variety of reasons quite apart from having a center available to others. We would like to see how we can explore the use of that for our own research.

Mr. LUJAN. Do you foresee a lot of university use of it—other universities?

Dr. CHAUDHARI. Yes, and other corporations also. For example, a number of corporations have expressed interest in this, at least from newspaper accounts, in joining the Cornell Center to use their equipment.

Mr. LUJAN. Do you find that to be the case, that the equipment is available at many laboratories that the Government owns all over the country, that universitites have access to them?

Dr. CHAUDHARI. I think the university community is very diverse. The scope of research goes all the way from a one-man effort to groups of efforts, and also the kinds of research we do is very, very varied, and what you find is, as you talk to people, where people have a need for a particular piece of equipment, and they don't have access to that equipment in their own university or it's too expensive, they will make contact there as much as they can.

A good example of that is, of course, our National Synchrotron Light Source. It's expensive, and it's centralized. A large university faculty combined with university and industry can own a beam line there to do research. I know of examples in our own corporation, and I know other corporations do the same.

So, you will find where there is a special piece of equipment which is expensive and specialized, that industry, universities, and national labs will get together, but is it as, you know, common as it ought to be? That is hard to answer.

There are those who feel it isn't worth their while to go all the way to a Government lab to do something that may be 700 miles away, or they don't have a travel budget, or their are other restrictions on priorities and research results which they don't wish to share.

Mr. LUJAN. From the standpoint of the laboratory, do you find it readily accessible?

Dr. CHAUDHARI. The big industrial labs are accessible to the universities.

Mr. LUJAN. I am talking about the national labs. That is, the ones we have control over.

Dr. CHAUDHARI. Yes, I see. At least our experience has been that they are very open and receptive to ideas. If you have research you would like to pursue, fine, and it's something they have available, they are receptive.

Dr. ZDANIS. Certainly from the university point of view, they are very accessible, yes. There are two types of research instrumentation, and I would like to draw the committee's attention to that once more.

There are the instruments used mainly for service, making measurements on a repetitive basis, et cetera. Those types of instruments are very amenable to sharing. But there are other types of instruments where you are trying to push back the boundaries of what is measurable or to change the technique for measurement. Those you have half apart most of the time. You are changing things. It's not really feasible to share those types of instruments. Yet, they may be equally expensive. So, some things are feasible to share, others are not. The cost of sharing not only includes transportation to remote sites, but it includes the removal of that particular expert from his home base and to some—the reason for an expert to be at a university is to provide informatin to his colleagues, to teach the students who are there, and then he is off at some remote site doing research. As good as that might be, he is not available to his local community, and that is a real cost.

Mr. LUJAN. I was thinking mostly in terms of my home area where, fortunately, we have superb national laboratories right at our back door. But I understand.

Dr. ZDANIS. You are particularly advantaged.

Mr. LUJAN. Thank you.

Thank you, Mr. Chairman.

Mr. BROWN. Mr. Morrison.

Mr. MORRISON. Thank you, Mr. Chairman.

I have questions in two areas. First of all, obviously some of us do have our biases as to particular institutions, and I happen to represent a rural area that has several smaller universities. I believe Chairman Fuqua has, in a bill that he has introduced, Mr. Chairman, a provision that a set percentage of funding be made available for smaller universities. Do you have any reaction as a group to that sort of a concept?

Dr. ZDANIS. Perhaps we should ask the association members to respond to that.

Mr. GOLDBERG. That is a particularly difficult question. One would, at least I guess—I will express an opinion. I would prefer that we deal in terms of good science and merit of the best science, if you will, and that both grant funding and equipment programs go where the best science is being performed.

I also worry about set-asides. No matter what position you take, you have to wonder when you do that whether all of those funds are being well spent. That doesn't mean that you will always make the right decisions when you choose merit.

I don't know how else to answer that. I am not for set-asides, and I am not against a set-aside, but I view that as a set-aside, and I worry in some way that that money goes where it does the most good.

Mr. MORRISON. We don't have the privilege that you have, both for and against set-asides. I can certainly see your point. I guess a concern I have is that we are included—and I look at your figures: 54 percent of the investment Federal, 32 percent State. Obviously these are taxpayers' dollars, and we would like to buy the best science with that investment. However, I think there will probably be a tendency to say, "Let's see if we can spread this across the face of the country a little more than to a selected group of institutions who by their reputations have established outstanding records of good science." Well, I guess we will return that particular decision to the political arena, Mr. Chairman.

The other question I had in just glancing through your report—I didn't get into the details of the blue book which, of course, is the complete report— I noticed, Dr. Hunt, in your comments you mentioned leasing twice, but only in two particular ways. One is that there should be longer lease opportunities for State or institutions that have only 1- or 2-year State budgets to work with, and the other was to develop more expertise at the university level on leasing than long-term debt structuring.

I wonder if your panel spent any amount of time, perhaps, on a new innovative approach on leasing to encourage leasing of equipment. It was mentioned that the tax incentives we have provided have encouraged businesses to make equipment available on some basis to university programs, but is there a possibility of going with more leasing since the life of this equipment seems to be short and maintenance is a problem? Should we devise at the Federal level some mechanism using tax incentives, and perhaps other financial rewards, or leasing programs in which the university would actually not acquire equipment, but in response to a research grant, that equipment could be leased for the tenure of that particular grant?

Dr. HUNT. Certainly a lot of leasing is going on at the present time. I think our review of the situation would indicate that, first of all, leasing is costly—is a more costly approach, and I think you have to look first at whether it's financially advantageous to—whether you should own the equipment or whether you should lease. In other words, there may be a financial advantage to owning equipment if it's not going to become technologically obsolete than a long-term lease where it would be a much more costly approach. There are innovative ways, however, to structure leases so you can obtain ownership at the end of the lease, and institutions have used municipal leases where tax exempt rates are obtained.

I think in the report we review a whole range of financing approaches, some of which result in—most of which result in ownership of the equipment as opposed to simply leasing the equipment. But the advantage of leasing, as I see it right now, is the ability to spread the cost over a period of years as opposed to having to pay for the equipment up front. Most grants do not, or a project-oriented system does not provide sufficient funds to acquire or provide for full cost of the equipment up front. But it has to be paid for, and paying for it over time has pushed people into leasing as opposed to purchasing and has then pushed people into innovative forms of leasing which result ultimately in ownership. I guess my problem is that leasing tends to be at a higher cost.

Mr. **Morrison**. The cost you don't write off as a tax advantage to an institution because it's automatically exempt anyway.

Dr. **Hunt**. That is right. And we reviewed carefully, and with our consultants, alternatives financially that are being used in the marketplace today, various forms of tax exempt financing.

But again, the big problem is who will pay for it ultimately? In other words, the debt has to be repaid, and the interest has to be repaid, and that has been without an assured or a systematic and rational basis of payment which, down the road, has sort of precluded people from institutions getting heavily into the debt financing arena.

Mr. **Morrison**. Is it——

Dr. **Hunt**. I don't know that I have answered your question.

Mr. **Morrison**. Well, you helped, and obviously you have given the issue some thought, and that was my basic question. Is it of significant importance that an institution, as a result of a research grant, end up with the equipment? The equipment being there means that somebody will do something with it, and it adds to the ability of that university to attract other research efforts or to be attractive from an academic point of view, at least.

Dr. **Hunt**. Yes, I think it is. Once you have ownership, too, you have the ability to work hard towards transfer of that equipment among laboratories so that it remains a useful piece of equipment, and that you only pay for it once. That is why I think that just a straight lease is not always the best approach.

Mr. **Morrison**. Thank you.

Thank you very much, Mr. Chairman.

Mr. **Brown**. Mrs. Meyers.

Mrs. **Meyers**. Have we—I'm sorry I didn't get here for the earlier part of the presentation. I was at another meeting.

I presume that the equipment we are talking about is primarily computers?

Dr. **Zdanis**. No, ma'am.

Mrs. **Meyers**. Tell me what other kinds of equipment we are talking about.

Dr. **Zdanis**. Scanning electron microscopes, mechanisms to assess surface phenomenon, materials handling equipment, materials construction equipment, instrumentions to measure radiations, both optical and nuclear, in order to assess all kinds of properties of materials. So, there are a whole range of important university research equipment which are not computers at all. Many of them are now incorporating computer components in order to help the data analysis and data gathering components of that equipment, but that is not the primary focus of the instrument itself.

Mrs. **Meyers**. Has this problem always been with us or is this something that has happened fairly recently just because of the amount of equipment that has been developed and the fact that it's outdated earlier?

Is this a new--I was on the 1202 commission at the State level, and I don't recall that this was as much of a problem with our State universities at the time. That was in the 1970's, however.

Dr. **Zdanis**. The development of sophistication in equipment has certainly escalated recently, so that the equipment becomes obsolete much more rapidly now than it did 4 or 5 years ago. The techniques that are being used in various fields are also changing rather rapidly. If I can take an example from the medical community, there are PET scanners and CAT scanners and NMR devices, none of which were really applying to those fields 5, 10, 15 years ago, so the techniques are changing fast.

That is hurting. There is no natural law which says how equipment needs to be used. The scale that we have to use for universities is what competition has out there, because the reason for the universities to be in the research business is to be at the cutting edge. The cutting edge is defined by whoever is doing the most advanced work, whether that be within the university community, within the industrial community, or in the foreign countries. It's that scale, that measure, that we are using to analyze the properties of the university state right now.

Mrs. **Meyers**. When you talk about private support and that we need more private support for the kinds of training equipment that we need, I guess, in my experience, contributions to university research have usually been dollars.

Dr. **Chaudhari**. That is correct.

Mrs. **Meyers**. Do these private concerns, either corporate or others, designate that they want this to go for scholarships or some special thing? I don't know why these dollars are not being used for equipment, I guess, is what I'm saying. Why is this a problem always?

Dr. **Chaudhari**. I think two points are to be kept in mind. First, the private contribution of equipment is a very small fraction of the total needs of the Nation. Right now, it's about 9 percent. At least in 1982-83, the National Science Foundation survey found that private equipment contributions amounted to 9 percent of the equipment the universities used.

Private support has increased substantially over the last decade, most of it from corporations which tend to be more and more ear-

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marked for research and development. However, corporate support comes in many forms. For example, if I am working for a company, then if I donate $100 and the company will double that and will give it to the university, I must specify I wish to give it for a graduate fellowship, or I may specify to just go to a department, and the corporation will simply match that without specifying that, "No, the $200 I gave should go somewhere else." So the support that goes to universities comes in many different ways. Most of it is not specifically earmarked that it should go for equipment. Should it be so earmarked? That issue is complex because the amount of support and the way the support goes in can be very small or it can be quite large. It would be a difficult thing to do.

Mrs. **Meyers**. Thank you.

Dr. **Hunt**. I might add most donors do designate a program or an activity they want their donation to support which is a restriction that institutions obviously abide by, so that scholarships or endowment shares is the way it has to be.

Mrs. **Meyers**. Do you find the States are establishing consortia of all of their universities and working together or do we need to do more of that? I just think we are going to see fewer dollars being available from the Federal level, and certainly while the States are more solvent than the Federal Government, a lot of States have problems too. And I think that unless we can pull more from the private sector, the dollars just won't be there. And I don't know if we can do that. So it looks almost like our emphasis should be in trying to get people to work together or some other devices along that line rather than just saying, "We need more money," because obviously we do. And I wish it were there because I'm very supportive of what you are saying.

Do you find that States are working together within their borders?

Dr. **Hunt**. The first thing we have to do, I think, is sell States on the idea that they have a very important role in research. I think that State funding has by and large been focused on the instructional aspect and missions of the institution and has not, except for land-grant schools, I think, has not extensively supported research. So, we have the first hurdle of getting a recognition at the State level that—that is in our report—greater recognition at the State level that they have a role to play and that increased funding is a a part of that.

I think because the problem is so widespread and is getting a lot of publicity, I think there is some recognition now at the State level just beginning to emerge, so to speak. It's a time and activity, now, to be expanded. States have not seen that as their role, necessarily.

Mrs. **Meyers**. It's beginning to happen, but maybe not—I think it's beginning to happen for economic development reasons.

Dr. **Hunt**. That's correct.

Mrs. **Meyers**. In some respects, States are saying we want some high-tech center, and they know that to do that, they have to have a really solid research institution in their State, and so they are going to go that way.

I know that we have done several things. One of the things we did in Kansas was to have State tax deductions for any contributed computer equipment or any other equipment that could be useful in research and a lot of tax deductions. I imagine a number of States have gone that route, but in terms of economic development, I think they are going to begin to see more emphasis there.

Dr. **Zdanis**. I believe you are correct. For private donations to universities, the ERTA tax law also was designed. One of the sections of it was designed to encourage that, and it has worked in a number of cases. So, one of the reasons that you see some more of the private sector donations being targeted to instrumentation is because of the effect of that particular law.

Mrs. **Meyers**. Thank you.

Mr. **Brown**. Mr. Fawell.

Mr. **Fawell**. Thank you.

Mr. **Brown**. Could I ask Mr. Walgren if he would be kind enough to chair?

Mr. **Walgren** [acting chairman]. Yes, of course.

Mr. Fawell, you may proceed.

Mr. **Fawell**. Thank you, Mr. Chairman. I apologize, too, for being Johnny-come-lately, not only to this meeting but to the Committee on Science and Technology.

One question that I have that dovetails the previous question a bit is I gather most of the Federal contribution is research, and the equipment comes in as part of the research grant. Is that a fair statement?

Dr. **Zdanis**. A fair statement, yes.

Mr. **Fawell**. What about separate programs which are geared only to equipment purchases and, throwing in also matching funding that would be required, and—then I will stop there. I have a question beyond that, but what about separate programs?

Dr. **Zdanis**. There are a number of agencies now that are trying that as an auxilliary emphasis. The Department of Defense, for example, has run that program for 2 years now. The National Science Foundation is starting that. Yes, that is a fine catchup mechanism for addressing this particular program. It has done well. We hope that other agencies will include that in their programs, too, and that funding be allocated for that purpose.

Mr. **Fawell**. Does that require you, usually, to have matching?

Dr. **Zdanis**. It does usually require matching.

Mr. **Fawell**. On what percentage is it, by and large?

Dr. **Zdanis**. Fifty percent is not atypical. One of the difficulties with matching is that it's not necessarily specified, and so there is a lot of negotiation about what percentage that must be, and that presents the universities with a great deal of internal deliberations as to how to try to bid for this. If we are in a program where there is only a probability of 10 percent that we will get one of these, should we allow 10 investigators to go forth and take an average that we will not have to provide the matching funds for all 10 instruments? We get to play Russian roulette to some degree.

Mr. **Fawell**. One other point. Several weeks ago, I heard our new Secretary of Education make the statement that some of our more well endowed universities have indeed got tremendous increases and really were not—could not be—classified as financially needy at all. Have you considered the idea of a financial need factor? This gets back to the question of some smaller universities and colleges that may indeed need more attention here, and some of the very, very well endowed ones that may not be eligible. I'm talking about a financial needs test, for instance. How would that strike?

Dr. ZDANIS. One of the problems with establishing financial need is "Compared to what?" If you compare it to aspirations, the needs of some of the more well-endowed institutions may, in fact, be as great as those of some smaller institutions.

Mr. FAWELL. Absolutely, yes.

Dr. ZDANIS. So, it's against that measuring stick that I have difficulty even trying to respond to your question. I know that some of the places where more research is currently done are probably the places where some of the big step functions can occur and where industrial communities may be willing to participate in joint efforts where they may not be willing to participate in efforts at other institutions. So, against that much larger need, they may be financially deprived.

Mr. FAWELL. Do our agencies, at any time, though, take a look at what funds indeed may be available by a given university and say, "Well, look, you have a worthy project"—say Harvard or Yale—"obviously there are programs there that would be more advanced with greater aspirations," and all that. But you are very well-endowed, and perhaps a much higher contribution factor ought to be considered in reference to your project, lofty as they may be in the interests of being able to have elementary-up service equipment for a greater number of our universities.

Dr. ZDANIS. That negotiation takes place every day between the program administrators and the principal investigators.

Mr. FAWELL. It does.

Dr. ZDANIS. And the program administrator will say, "Gee, that is a great project. Why don't you go see your dean and see how much more money you can get out of him?" By George, the principal investigator will be in the dean's office that afternoon.

Mr. FAWELL. Thank you.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Fawell.

Dr. Zdanis, you start out your testimony focusing us on the efficiencies of procurement and so on, and yet, obviously, there is a big dollar amount involved someplace. How much is it?

Those recommendations for changes in operation procedures might make things work very well and critically better for an individual project. On a percentage basis, how much of our problem do you see as solvable by efficiencies and regulatory controls as opposed to the need for new funds?

Dr. ZDANIS. A very small percentage, very small percentage.

Mr. WALGREN. Certainly it's a high frustration factor.

Dr. ZDANIS. Very high frustration factor, and it produces nothing of value for the country, and therefore we shouldn't be doing some of these things.

The other thing that some of the barriers produce is a lack of leverage of the Federal funds which are available to commingle them and use them with other resources, so that even without additional moneys, different sources of funding can be brought to bear on the problem.

We would like to remove those barriers.

Mr. **Walgren**. In your explorations, did any problems with the manufacturers of equipment, being in a position to be overreaching, raise their—raise the specter of the funds being taken advantage of by manufacturers of unique equipment? There are allegations of goldplating of instruments that would not be necessary for the experiment that would deliver more money to the manufacturer. Is that a problem in this area that we have to be on guard against?

Dr. **Zdanis**. We did not see any, I don't believe. I don't believe that it's a problem. The type of instrumentation we are speaking about has a fairly narrow market. It's like selling automobiles to race car drivers who know everthing about automobiles.

These are the people who use, design, and to some extent, enhance the design of equipment that you are trying to sell the commercial product to. You can't easily snooker them with additional goldplated items.

Also, the limitation of funds is such that the principal investigator will be negotiating with the purveyor of the instrument to take all of the things that may add to the cost, but don't provide the fundamental focus of the instrument. In fact, that happens to a detrimental extent to some degree. Some major pieces of data acquisition equipment may be withdrawn from the purchase order in order to get the price down that can be afforded, and so the instrument doesn't produce the amount of data in a timely manner that it could be doing if they only had the ability to have this extra piece of equipment. So, I see the problem in exactly the reverse.

Mr. **Walgren**. Instinctively, where there is a Government pocket used to pay for the process or an effort, and the funding may be understood to be forthcoming, the buyer of the equipment, under those circumstances, would not necessarily be competitively sensitive to holding costs down. I don't have any experience in that area, but I'm just trying to dig through you people who have looked at it and dealt with it somewhat, and see whether or not there is a substantial problem of overpayment for what are, admittedly, unique items. If not, it would seem that we could be, perhaps, less regulatory in our approach at OMB and other places. But if it's a problem, of course we have to be more on guard.

Dr. **Zdanis**. I would like to give a quick response and turn to Ray. I do not know a principal investigator who is funded at such a level that he would not take every available dollar and use it for another purpose if he could avail himself of those additional dollars. So that the principal investigators, because they're trying to get out more research, will be very, very prudent and have been very prudent about spending those dollars in the most efficient way.

Mr. **Walgren**. Does the role of a principal investigator being confronted with a sole source for something he needs put him in an untenable position?

Dr. **Chaudhari**. There are very few pieces of equipment where you have a sole source. It's a fairly competitive market.

Dr. **Hunt**. The one comment I would like to make is we all do have our own purchasing departments, not just a principal investigator involved in this. There is also, in a major university, a central purchasing unit which is very much involved. It's sort of a team approach in terms of the acquisition of equipment. As one who comes from a State university, we have a State purchasing department that is also involved, and in fact, until recently, we were very tightly controlled by State procurement regulations. That has now, at the State level—one of the advantageous things that has happened to us—the State now has delegated to the institution procurement authority which has substantially enhanced, really, our ability to meet the researchers' needs on the one hand, and still have a central overall policy that would, I think, preclude the kind of thing you are talking about. So, we have not experienced that in our case.

Mr. **Walgren**. Thank you.

Mr. Lewis.

Mr. **Lewis**. Let me also apologize for not being here for your presentation, but skimming through it, it looks very thorough.

On page 10 you have a recommendation that something be done to make prior approval less cumbersome. Can you give me a scenario of what you mean there, such as setting a $10,000 minimum level for the universities' inventories?

Dr. **Zdanis**. Right now, in order to abide by the regulations in A-21 and A-110, in order to assure that we are not duplicating a piece of equipment within the university that is available for research, when a principal investigator puts forth a purchase request to the purchasing department in the institution, he has to screen their inventory to see if that piece of equipment is available for use within the institution. The screening now has to occur if that instrument is more than $300. We claim that that requires an awful lot of additional paperwork and screening burden for a dollar level which is really not prudent to share. You would capture, in that case, capture a majority of the value of the inventory and cut down a majority of the paperwork by raising the level at which that threshold screening must occur to a reasonable level like $10,000.

Mr. **Lewis**. I see. You also mentioned equipment sharing. Are you speaking of within the university itself or with other universities in close proximity?

Dr. **Zdanis**. Yes, both.

Mr. **Lewis**. That is all I have, Mr. Chairman. Thank you.

Mr. **Walgren**. Thank you, Mr. Lewis.

We have a vote on now, and if you have the time and could suspend for 10 minutes, it would make sense, I think, to allow us to vote.

Let me ask Mr. Volkmer if he wanted to ask questions at this point.

Mr. **Volkmer**. No questions.

Mr. **Walgren**. I hate to keep you here for just a couple of things that I might have from scanning your statement.

Can I ask when we say this problem is a problem that is so substantial it can't be solved except by a sustained investment program, can we put a dollar figure on the problem? Laboratories would have to roll over their equipment every 5 years, apparently. Are you able, in this report, Dr. Zdanis, to put a dollar figure on size of this problem?

Dr. **Zdanis**. No, we did not investigate that. We understand there are additional efforts underway to try to establish what that level is, but we did not within this report address that problem.

Mr. **Volkmer**. Could I ask a question in that regard?

Mr. **Walgren**. Mr. Volkmer.

Mr. **Volkmer**. The university research community would be very hesitant, I'm sure, to recommend that we increase funds for equipment, research equipment, while we decrease funds proportionately for actual research grants. Why not?

Dr. **Zdanis**. That is certainly correct.

Mr. **Volkmer**. See, the trouble we have with these deficits is where do we find the extra money?

Dr. **Zdanis**. I understand the problem.

Mr. **Volkmer**. One thing is to take it out of the present amount and earmark it for equipment, but the other is to add. Where do we get the additional?

Dr. **Zdanis**. I understand the problem.

Mr. **Volkmer**. Do you have a situtation where we can find it?

Dr. **Zdanis**. No, I do not. I don't have the global view that you do.

Mr. **Volkmer**. I agree with you on that, but I think you understand the problem.

Dr. **Zdanis**. I understand the problem, yes.

Mr. **Walgren**. As I understand it, a substantial amount—you indicate a majority of support for equipment is obtained in the process of competitive proposals, approval of competitive proposals. If a substantial part of the equipment is obtained in that way, where does the overall relationship of the equipment that is actually procured—where is that taken into account?

If one research project is particularly interesting to NSF that doesn't mean that that equipment fits with any other more comprehensive approach towards the laboratory that is involved.

Dr. **Zdanis**. Remember that before a proposal is allowed to go forward to an agency, the university has signing procedures that it goes through. At our institution, the sponsoring project office has to sign it, the department chairman has to sign it, the dean has to sign it. The institution undertakes an obligation also when it accepts a research proposal and, therefore, the proposals that they allow to be submitted to the agency do, at some level, have an institutional goal.

Mr. **Walgren**. I see. We have a vote here, and we should break. If I could ask you to just suspend for a couple minutes, I will come right back, and it will not be long.

Dr. **Zdanis**. We would be privileged to.

Mr. **Walgren**. The committee will recess for this vote.

[Recess.]

Mr. **Walgren**. Gentlemen, I appreciate your staying on. I don't know how much more we should explore for the record. I was a little reluctant to simply stop because we had a time pressure of the bells.

Doesn't the universities' interest, in a sense, run counter to peer review interests of the agencies in selecting the most interesting projects to them? When you say that we should be assured that there will be some coordination of instrumentation because the proposals, competitive proposals, are reviewed by the university, what might be of most interest to the National Science Foundation might not fit with the university's equipment acquisition program. Wouldn't that be not necessarily something we could rely on to coordinate these matters?

Dr. **Zdanis**. That is certainly true. There are, of course, the specialized equipment grants which are available to help us in that regard, and there is the private sector that we call on periodically for both instrumentation itself and the funds with which we can purchase instrumentation.

From a coordination——

Mr. **Walgren**. Four percent.

Dr. **Zdanis**. Four percent. That is true. But to a considerable degree, the kinds of things the university will be interested in fostering are those things where the investigators are meritorious enough to be able to get research grants.

We think that it enhances the viability of a proposal to have it presented in a way which can be coordinated in efforts across the institution. So, although they are not identical, they are certainly—they are looking at the same problem, and they are not as diametrically opposed as you may imagine.

Mr. **Walgren**. I wonder if there is any way to have an instinct for or general impression of the degree of instrumentation as provided by special instrumentation program for the Federal Government?

As I understand it, the Defense Department has a particular program that is instrumentation design. The National Science Foundation tries to take it into account even though they—I don't know that they are a line item in the National Science Foundation instrumentation account—but the point is that the Federal Government provides 54 percent of all the instrument funds, and a portion of that is coming under specific instrumentation programs coming from the Federal Government. Do you have any instinct for the matter of how large that proportion is? How much of our instrumentation is done indirectly, and how much of it is from the Federal level—is being done directly with the purpose of providing the instrument?

Dr. **Zdanis**. I would turn to Milt.

Mr. **Goldberg**. I can't give a percentage answer. I only know that the largest proportion is being provided by individual project grants.

Mr. **Walgren**. So, the larger amount would come through the indirect method, obviously?

Mr. **Goldberg**. I don't know if I would call it indirect, but certainly individual projects, at least.

Mr. **Walgren**. You folks would advocate a separate program of grants for equipment only? I gather the problem is large enough that you would like to see the Federal Government involved in this with a separate program for equipment only that presently does not exist.

Dr. **Zdanis**. Those have been very helpful where they have occurred, and we would encourage other agencies to do likewise.

Mr. **Goldberg**. We would advocate a whole range of activities of which that is one. As we suggested in the recommendations, there are a number of changes that could be made in Federal regulations, and the universities could tidy up a little, but it takes a range of those activities as well as direct Federal investment, and as you say, indirect Federal investment and institutional investment, to really deal with the size of the problem.

Mr. **Walgren**. Do you feel that there is a need for a mechanism to coordinate the efforts that we are making to solve this problem? Suppose you had a direct Federal instrumentation grant. Then you have the competitive applications, then the private sector coming in with 4 percent, the universities with 32 percent. If we are falling short, obviously somehow we have to set priorities to fund some areas and not others. Even if we are not falling short, it would seem that there would have to be a constant monitoring and adjustment and an attempt to backfill where deficiencies are noted. What do we have that we can hold out to the public that they should be assured that that will happen effectively?

Dr. **Hunt**. Two things come to mind. One is that any program should build in it, it seems to me, incentives that would enhance, incentives that would enhance other sources of support such as increases in State and industrial funding, so that you don't want to create something that will cause them to withdraw or allow the Federal—increase in this program to adversely affect funding from other programs. So, I think that it should be a combination and that the program should clearly create incentives maybe through matching or some other mechanism that will cause other sources of support to pick up as well. That is No. 1.

Two, it seems to me the project-oriented system—in a sense, you are correct. It doesn't make for good, long-range planning. One of the things that we have struggled with, I think, in our report is how can we deal with this thing so that major items of equipment, the cost of major items of equipment, could be spread over several years rather than having to force it into an individual year. That would lead to greater planning, I believe, certainly would lead to more institutional involvement in the acquisition process, if there was a spreading of the cost as opposed to forcing everything up front as part of the individual grant itself. Now, that is difficult, and I say we have struggled with it and have not come up with an answer of how to do that, but I think that that would lend itself to more institutional involvement, give you greater assurance that it wasn't just the laboratory making the decision, but it was an institutional planning process that was in place.

Mr. **Walgren**. To the degree you use debt financing, that tends to bring that in.

Dr. **Hunt**. Tends to reinforce that, yes.

Mr. **Walgren**. Ms. Woolsey, do you have any suggestions we should focus on to encourage debt financing approaches in the universities?

Ms. **Woolsey**. One of the things that became clear to us when we visited universities is that deciding to go into debt does force a more centralized view of what the overall institutional future is going to be. That is difficult, sometimes, to pull off on campuses because universities tend to be at least as decentralized as the executive branch of the Government.

I think that the ability to use more modern techniques of debt financing and depreciation and deal with program officers in the agencies directly on what one's needs are—pregrant OK's for putting in the order for the new NMR machine because it takes 8 months to get one once you decided which one you want, and that means if you have to wait until the grant is awarded, you cannot do the research for 8 months. Just minor administrative—what seem to be minor administrative details, I think, would smooth the way psychologically for the people on campus to do a considerably more efficient job.

I spent 12 years in the executive branch before I joined the private sector, and I found most of our time was spent fighting among agencies. Coming back to this project, it became clear that a lot of time is still spent fighting among agencies with the universities and sometimes the clubs and that if one could—I realize this wouldn't be possible—could impose more consistency among agencies' interpretations and more coordination in terms of what is allowed, what is encouraged, it would enable those very, now very conservative central administration figures to become less conservative because they would not have to meet the most conservative guidelines.

Mr. **Walgren**. Thank you.

Let me recognize Mr. Slaughter.

Mr. **Slaughter**. Thank you, Mr. Chairman.

I think my questions have been asked by now but what Dr. Hunt was saying, and some problems are outlined in the report, if institutions could put aside so much money each year for use of depreciation factors, it wouldn't be desirable but we in our case don't have provision for that in State policy. I don't know whether other universities are allowed to use depreciation allowance, I don't know.

Dr. **Hunt**. I am speaking to my former director I want you to know here, but in terms of State-appropriated funds, that is absolutely correct. In the area of research grants and contracts where indirect costs are retained by the institution, use allowances or depreciation are funded amounts that are retained by the institution and can be applied to the purchase of equipment.

I think what we were struggling with was the question of whether—as opposed to doing it as an indirect—as recovery through the indirect mechanism, of being able to charge the cost of equipment to multiple years of a grant as a direct cost, or to leverage the transaction through debt if you had the assurance that payments would be made, funds would be available for that. That would help to first bring the institution more into the picture and provide for greater and more strategic planning, and greater institutional involvement in the equipment area. And second, it would permit, I think, acceleration of the—permit us to chip away at the backlog or the deficiency that now exists.

Mr. **Slaughter**. Thank you. I don't have any further questions.

Mr. **Walgren**. Thank you.

Let me ask one other question.

In the immediate response to the shortages and deficiences, there has been the thought, well, let's just pull the private industry in here and they have up—to—date equipment and there are ways that perhaps the universities could work with the private sector to let their students have access to modern equipment. I suppose the correlary is that as governmental agencies we could sit back and watch TV at that point.

After about a year of that, what I heard was that private industry doesn't want students in there fooling around with their equipment and that that was a very, very weak reed to hope for and lean on. Could you give us any measure of the degree of availability that the modern—the degree of availability of those modern instruments to the university population?

Dr. Chaudhari. Let me try to answer that with a slight editorial comment if I may.

The universities do research in very, very broad areas and industry in general will pick an area of research that is of interest to them, and so if you add up all the research that goes on in industry, you will find it is a small fraction of the total research going on in the universities. I think that is important to keep in mind.

The only commonality is a small fraction of that. If you come into that small fraction you can ask: "Would we allow a student to come in and with all the rawness of a student coming in and playing around with sophisticated equipment; would we be willing to spend time on that?" Up to a point, yes, but it would very much depend on the individual investigator. But nowhere near the kinds of students you need to train in the university. So I don't think that is a solution to the problem.

I think it is a suggestion, a gesture that allows you to build good will with the university, helps the university, establishes contact with researchers. That is just as important. To that extent, I think it is very useful. I think we ought to encourage that, yes.

I think to solve—is sophisticated equipment available to university researchers? The answer is yes, where there is commonality of interest. That brings you back to the fact there is only a small fraction of research that has commonality of interest. And where there are labs where there is state-of-the-art equipment, that is a factor.

These are all steps to be taken, but they are small steps toward solving a major problem.

Mr. Walgren. I hear you saying that that would really apply to the individual researcher who had a particularly interesting project that was—and was able to establish the confidence of the corporate counterpart and it would be a very individual relationship.

Dr. Chaudhari. Yes, sir.

Mr. Walgren. That certainly would be nonexistent, essentially, with respect to training of multiple students university-wide, or training aspects that the universities engage in, such as in engineering and the like.

Dr. Chaudhari. Yes; the emphasis at the industrial lab would not be on training. It would be more in research and the process of doing research where the student would learn.

Mr. Walgren. Well, if there is nothing further then——

Mr. Slaughter. I have no more questions, Mr. Chairman.

Mr. Walgren. We would really want to express our appreciation for being a resource to our committee and our task force, and perhaps we can develop some of these areas that have been touched on by the members and some that have not been touched on, and we will submit written questions for you to respond.

With that, we would adjourn the task force until next Tuesday at 10 a.m. Thank you very much.

Mr. **Zdanis**. Thank you very much for having us.

Mr. **Chaudhari**. Thank you.

[Whereupon, at 11:48 a.m., the task force was adjourned, to reconvene at 10 a.m. on Tuesday, September 10, 1985.]

[Questions and answers for the record follow:]

QUESTIONS FOR THE HEARING RECORD

FINANCING AND MANAGING UNIVERSITY RESEARCH EQUIPMENT
Task Force on Science Policy

September 5, 1985

1. "This [testimony] seems to imply that funds have been available for this special purpose, although in too small amounts, and it suggests that the universities, the research agencies and the research community in general somehow failed to ask for increases in this special funding category. Is there not also a question of whether, over these 15 years, the priorities within the total science budgets, both within the individual institutions, and within the state and the federal science budgets have failed to deal adequately with the long-term, emerging and important need?"

Answer

Funds for equipment have indeed been available, but not in adequate amounts to support research instrumentation needs. Figure 3 on page 18 of our report illustrates the dropoff in total funds available and the decline of the federal portion in particular. The variation is in inverse time progression to the costs of instrumentation and the life cycle of state-of-the-art equipment. The figure shows that the problem still exists and that the issue has not been dealt with adequately.

2. "What is a 'critical experiment' [in this context]?"

Answer

The National Survey of Academic Research Instruments and Instrumentation Needs quoted on page 20 of the report, was designed and conducted by Westat, Inc. under the sponsorship and guidance of the National Science Foundation. Westat did not include a definition of "critical experiment" in its glossary of key terms. In the absence of such a definition we suggest language which, to the best of our knowledge, a faculty member might use in responding to the question. Critical experiments are experiments at the forefront (cutting edge) of the discipline, which the state of knowledge in the area indicates are both: 1) necessary to advance our understanding and development of the field; and 2) now possible because of current state-of-the-art technology.

3. "How large a percentage is today obtained through competitive proposals prepared by individual faculty members? What are the advantages and disadvantages of this way as compared with providing equipment from sources separate from the research proposal such as from university sources or government equipment grants?"

Answer

The 1980 NSF report entitled The Scientific Instrumentation Needs of Research Universities provides an overview of the variety of support mechanisms available, given adequate funds. It discusses the advantages and disadvantages of individual project grants, special instrumentation grants, regional instrumentation centers and other sources, and in the process, makes an eloquent case for maintaining diversified funding options to respond to university needs. Both the individual research grant and the equipment grant mentioned in your question are competitive, as are most funding sources available to universities. Data on the percentage of research equipment obtained through competitive proposals has not been formally collected. Dr. Eric Bloch, Director of the National Science Foundation estimated recently that approximately 20 percent of total NSF resources is allocated to acquisition of equipment. It is unlikely, in his estimate, that the percentage can be increased to 25 percent, although he considers this a desirable goal.

4. "It does not appear too far-fetched to suggest that the general deterioration of important parts of the research infrastructure such as instrumentation must be attributed, at least in part, to these policies of little planning and a priority on personnel. Do not universities, realizing the problem they have created for themselves, have an obligation to think ahead and balance their priorities better?"

Answer

Universities do indeed acknowledge their responsibility for strategic planning and confirm their obligation to balance their priorities effectively. These issues are addressed on page 74 of our report. Universities feel vulnerable because uncertainties of federal funding patterns make projections difficult and unexpected cutbacks confound existing plans. University basic research works best in long term cycles. Yet, in times of sudden budget shifts, universities feel the obligation to protect their human resources, as their most valuable asset. Once a research team is disbanded, it is extremely difficult to regroup. Clearly, industry also experiences constraints, but, operating largely in the procurement mode, their constraints of planning and setting priorities are of a different nature than those affecting universities.

5. "What explanation is there for the fact that most other universities have not done something like the Iowa State University Equipment Inventory Program (REAP)?"

Answer

Our report makes the recommendation that universities consider establishing inventory systems that facilitate sharing. One such system is the basis of the research equipment assistance program (REAP) at Iowa State University. REAP has many components in addition to shared use. For instance: acquisition of used equipment, screening, expert repair and calibration services, transfer, scientific description of inventory. The total package works well in the state of Iowa, given the research volume at Iowa State University, its geographic location and research emphasis. Because of its location, Iowa State University has generally greater difficulty in securing equipment maintenance and repairs than do universities in more populous areas of the United States. With funds provided by the National Science Foundation, Iowa State University made a sizeable investment in setting up the REAP inventory. REAP includes only research equipment, in the science and engineering area, selected to be of sufficient quality for research use. This inventory now exists as a specialized system, parallel with the much larger general accounting inventory. Other universities which consider setting up comparable systems, are acutely aware of the expense of start-up and maintenance, including the substantial faculty participation that is required to set up the expanded scientific descriptions on which the system is based. The total REAP system may not be cost effective for all universities, but most will find elements of it useful.

6. "How does the situation today with respect to the current state-of-the-art of instrumentation available to researchers compare with what scientists faced in 1965 or even in 1935?" Or, to put it in a different way, do scientists ever feel that they have available the most up-to-date equipment?"

Answer

Science itself requires the continuous development of instruments with greater sensitivity, precision and speed. Only by developing and using improved instruments and techniques can investigators push back the frontiers of knowledge. Our report concerns itself with the inability of the scientific community to acquire the state-of-the-art instruments that their colleagues in the industrial sector and domestic and foreign competitors, are using in their day to day research. It is in the scientific enterprise itself and in the international economic and technological arena that the difference between 1985 and 1965 lies. Our technological and economic competitiveness cannot be maintained without recognizing the continuous need to invest in advanced research instruments and university laboratories.

7. "Why should it be the government's policy to pay the "full cost of research?" How can we justify the gradual broadening of indirect cost recovery on research grants into areas less and less connected to research under the "full cost" doctrine?"

Answer

There seems to be a fundamental misunderstanding about the meaning of the term "full costs of research." When the government funds an individual university research project, it never pays the full costs of that project. Federal funds help to house and conduct the project in an already existing institutional environment. Federal funds leverage institutional resources and may trigger other third party support. Unlike industry, universities do not receive independent research and development funds (IR&D). Universities build their own capacity through independent research and instruction from which their research base is developed. The significance of the larger institutional base that supports academic science must not be underestimated. Its value lies in the large group of scientific expertise with complementing talent put together carefully over a number of years, where dialogue among disciplines has been nurtured for decades. It allows you to bring to bear the concentration of a small group on a particular project for a brief period of time. Only the most direct "full cost" components are charged to the sponsors of the research project. The recovery of indirect costs is based on audited documentation of incurred research expense, pursuant to rules established by the government.

8. "One way to reduce the need for the government to be heavily involved in the detailed decision-making about moneys as they are budgeted, spent and recovered for such things as instrumentation, is block funding. In the long term, should federal science support rely more on such block grants and other mechanisms in order to decentralize decision-making to the universities themselves?"

Answer

Block funding, as exemplified by NSF's Materials Research Centers, is an effective way to decentralize governmental decision-making processes and to increase flexibility in granting prior approvals. There are others. PHS and NSF have implemented a variety of other mechanisms which delegate decision-making to the university level. The NSF Organizational Prior Approval System was expanded to all universities, after two phases of careful testing. It shifts the locus of decision-making with regard to certain budget approvals from the government to the universities. The PHS has recently completed its experiment, the purpose of which was to evaluate the effect of extending its existing prior approval list to universities by an additional ten items. We understand that PHS is satisfied that it can rely on the universities to manage their grants well. Target date for implementation of a comprehensive PHS Institutional Prior Approval System is April 1986.

We hope that other federal agencies will in turn be open to explore innovative ways to decentralize government decision-making. For that reason, we welcome the plan to make the State of Florida System the locus of a demonstration project on a government-wide basis.

9. "It now appears highly likely that the size of the pie from which all federal research support must come will remain fixed in the foreseeable future, or only expand slightly. If that is the case, where within that total research budget can we, in your opinion, make modest decreases in funding levels in order to provide the resources for the needs for scientific equipment at the universities?"

Answer

It is vitally important that we do not mortgage our future by failing to allocate appropriate resources to university research, including facilities and equipment. Even if the total R&D investment remains fixed, the health of the research enterprise can be maintained by further reallocations of funds from the federal development activities into long-term research. This general policy objective has been supported by the President's Science Advisor.

10. "How could this [research equipment problem] occur without anyone in either the universities or the government science agencies detecting that a gradual decline was taking place?"

Answer

The present situation is not a sudden crisis. It has been the focus of sustained attention. Pertinent studies referenced in our report, span the period of the last decade. The State of Academic Science, published in 1978, describes the status of federal support for university research and development from 1945 and traces changes through the mid 1970s. It speaks of the growing seriousness of the problem. The American Council on Education reviewed expenditures for scientific research equipment at Ph.D granting institutions for FY1978. In 1980, a report was published for NSF, The Scientific Instrumentation Needs of Research Universities. This was followed in 1981 by an update entitled, The Nation's Deteriorating University Research Facilities, a survey of recent expenditures and projected needs in fifteen universities. In 1982, the National Academy of Sciences sponsored a workshop on "Revitalizing Laboratory Instrumentation." All these studies were considered by the GAO for its review of equipment needs of U.S. universities, published in April 1984. Later that year, the Westat study, entitled Academic Research Equipment in the Physical and Computer Sciences and Engineering was published. The AAU/COGR/NASULGC study, on which these hearings focus, is thus only another in a long series of warnings sounded with increased urgency.

11. "For most of the decade of the 1970s and into the early 1980s the universities themselves behaved largely as dependents of the government, abdicating their responsibility for infrastructure and biding their time until federal facilities programs were resumed. In your view, can anything be done to bring about a change in this attitude on the part of the universities?"

Answer

Universities have warned since the late 1970s, as the quoted governmental witness acknowledges, that the research infrastructure is troubled. In response, institutions have not taken a passive position, far from it. Although government facilities investments stopped in the mid 1960s, universities have been and will continue to refurbish their facilities to the limits of their resources. But absent federal participation, university effort in real dollar terms has been eroded to the point that institutions generally are able to meet less than half of their accumulated needs. Since instruction and research require modern instruments and facilities, universities are acutely aware that the quality of their instructional programs, the faculty they can attract, and the quality of their research all depend on the facilities and support systems the institution offers to faculty, staff and students. This awareness requires competitive universities to adopt creative and activist strategies. Passive postures in the present climate are self-defeating.

12. "In your opinion, what would be the advantages and disadvantages of [such] a fixed percentage rate for the indirect cost coverage, and specifically, would it be helpful to the universities in giving increased flexibility to the acquisition of research equipment?"

Answer

To replace the audited reimbursement of expenditures with an arbitrary formula, in the sense of a uniform fixed percentage will not result in a realistic or equitable determination of indirect costs. It would not be based on the principle of cost reimbursement, so it would be arbitrary and likely to be unsatisfactory to both the universities and the government. Rates vary, depending on the size of the university, its organization, its geographic location, the nature of its research and the degree of support it receives. In different university settings, it is logical to treat the same kind of cost as indirect or direct. A statutory limit on indirect cost, ignoring individual circumstances, would not lead to a reduction in indirect cost, but at best to a redistribution, which would not settle the matter to anyone's satisfaction. COGR recently addressed this issue in greater length in response to the question on the Task Force Agenda "Is it possible to replace the present complex indirect cost system with a better system?"

13. "To what extent have the universities been setting aside the use charges as reserves against future replacement of equipment needs?"

Answer

The government does not reimburse universities for use or depreciation of government purchased equipment and facilities. However, the government has agreed that indirect cost may include an amount for depreciation or use allowance on research equipment and facilities purchased with university funds and used on federally supported research. Government reimbursement of depreciation and use allowance is committed to pay the bills for those prior university purchases. If an institution were to use those funds as a "set aside" to purchase new equipment and facilities, it could not pay for previously purchased items. The problem is one of obtaining funds for modern equipment, and one of the need for a systematic means of repayment of university research equipment purchases.

14. "How does industry manage to acquire and make available to their research staff the most modern equipment and what lessons can government and the universities learn from industry in this area?"

Answer

Industry clearly recognizes the need to invest in the latest state-of-the-art equipment. A glance at the most progressive U.S. corporations shows the benefits from these investments. Industry of course is supported by a favorable tax structure which allows it to use the accelerated cost recovery provisions of the 1981 Tax Act as one of many business incentives. When these incentives were not available industry was forced to be more conservative. To illustrate this point, it is interesting to contrast the effect of depreciation rates on the resources of computer chip manufacturing firms to those of regulated telecommunication companies, or the steel industry. One industry, for example, had to work with outdated switching gear because of a 50 year write-off restriction. The universities to this day are still laboring under unrealistic use allowance policies prescribed by the government. While industry may depreciate research facilities over a seventeen year period, it has only just been recommended that universities be permitted to assess the average useful life of a research facility at twenty years, rather than the presently mandated fifty years. On a parallel basis, the concept of average useful life of fifteen years for a piece of university research equipment, on which current use allowance reimbursements are based, is inequitable and unrealistic.

15. "The debt financing method has been explained in detail. What are the reasons, in your experience, why that financing method has not been more widely used in the universities?"

Answer

Our report discusses the constraints on debt financing in a special chapter (see pages 56-58) and surveys instruments for debt financing in Appendix 1. Essentially, universities are reluctant to use debt financing to a greater degree than they already do because there is no systematic means to assure adequate repayment and because debt limits future flexibility.

16. "Do we have any data on how much such [donated research] equipment is being donated to the universities?"

Answer

Data on gifts of company products and other property is reported as part of the 1983 - 1984 survey, Voluntary Support of Education, prepared by the Council for Financial Aid to Education (CFAE). Out of a total of $280 million, or 6 percent of total voluntary support, company products accounted for $116.8 million. Equipment giving is likely to be adversely affected by the uncertainty in the tax system, as well as market conditions and production schedules. Finally, it would be beneficial to instructional programs if the tax provisions were broadened to include donation of instructional equipment.

17. "Is the incentive on industry to donate research equipment to universities having the effect that modern equipment is being given to universities, or is it in fact obsolescent equipment that reaches the universities when industry replaces its own equipment with more up-to-date instruments?"

Answer

Under the old tax structure, only straight donations were attractive to industry. These donations were not linked to any stipulations regarding age of the donated equipment, and as a result, universities tended to receive older equipment. The Economic Recovery Tax Act (ERTA) of 1981 changed this to require that equipment be donated within twenty-four months from the date of manufacture. Universities are receiving modern equipment.

18. "What is the best administrative process to foster increased use of shared or pooled equipment within the institution or even among neighboring institutions? Would further centralization help?"

Answer

According to the 1984 NSF (Westat) report, nearly half (45 percent) of all in-use research equipment in the 1982 national stock was located in shared-access facilities. High cost instruments are routinely shared across department lines. As research instruments become more costly to acquire, operate and maintain, economies of scale operate to force naturally greater sharing, centralization and remote access. Decisions to share instrument resources, however, must be based on academic needs, expressed and directed by research faculty, in compliance with the principles which initially governed the acquisition of equipment. Administrative attempts to force shared use artificially generally do not work.

19. "How successful have the NSF Regional Instrumentation Centers been?" Is this a concept that should be substantially expanded, or is it limited to certain types of equipment?"

Answer

The 1980 NSF report, The Scientific Instrumentation Needs of Research Universities discusses Regional Instrumentation Centers at an early stage in their development. We do not have more recent assessments, but the number of these centers is not expanding.

20. "Do you see any merit in such an approach [grants for equipment] (which would be similar to what the Fuqua bill would do for research facilities)?"

Answer

There is substantial merit to instrumentation grant programs for large equipment. The success of the Department of Defense, University Research Instrumentation Program is concrete evidence of that. Similar programs have been introduced by NSF, DOE, and NIH. We refer to Appendix C in our report for a comprehensive list of available programs, and to the 1980 NSF report mentioned above, for a substantive review. However, such programs should not be seen by the investigators as a reduction in funds directly available to conduct research. They should rather become part of a comprehensive investment strategy that combines competitive grants for large, costly equipment with awards for smaller projects including instrumentation.

21. "Given that the federal government is estimated to have provided 54 percent of all instrument funds in 1982-83, how much is that percentage today, in your judgment, as the result of those initiatives?"

Answer

Data are unavailable to answer this question.

APPENDIX 1

VOLUNTARY SUPPORT OF EDUCATION

1983-1984

Prepared by the Council for Financial Aid to Education and jointly sponsored by the Council for Advancement and Support of Education and the National Association of Independent Schools.

Highlights

Higher Education

- Total voluntary support rose $440 million in 1983-84 to an estimated $5.6 billion, up 8.5 percent from 1982-83
- Corporate support rose 14.3 percent and provided a record 22.7 percent of all gifts. Gifts from nonalumni/ae individuals edged past those from alumni/ae for the first time since 1977-78

Reports from Participating Institutions show that

- Gifts of property totaled $279.5 million, including $116.9 million in company products
- Corporate matching-gift grants totaled $78.8 million
- Alumni/ae gifts to the annual fund rose 5.4 percent, the average gift was a record $113.40 and a record 20.4 percent of alumni/ae responded to annual-fund drives

Independent Secondary and Elementary Schools

Reports from the Independent Schools indicate that

- The 451 participants received $280 million in 1983-84 versus $276 million reported in 1982-83 by 480 schools
- Gifts from individuals accounted for 75.5 percent of all gifts
- A record 28.8 percent of alumni/ae gave a record average gift of $129.21 to the annual fund, a 6.8 percent increase over 1982-83

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Voluntary Support of Education 1983-84

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August 1985

A grant from the Reader's Digest Foundation assisted CFAE in meeting the costs of producing this survey.

Preface

This twenty-fifth *Survey of Voluntary Support of Education* has been jointly sponsored by the Council for Financial Aid to Education, the Council for Advancement and Support of Education and the National Association of Independent Schools, with the cooperation of several other national organizations. It is the latest in a series of studies of educational philanthropy dating from 1954-55.

The survey was completely restructured in 1983-84 to reflect the more precise and detailed definitions of sources and purposes for reporting gift income as defined in ***Management Reporting Standards for Educational Institutions: Fund Raising and Related Activities***, published in January 1983 by the Council for Advancement and Support of Education and the National Association of College and University Business Officers. While the primary definitions are essentially the same as those used in prior years, the more detailed breakdown of categories resulted in this survey collecting about twice as much data as earlier ones.

Voluntary support excludes income from endowment and other invested funds as well as all support received from federal, state and local governments and their agencies; in editing the survey questionnaires, CFAE deleted all income from these sources when so identified by a reporting institution. Any enrollment figures not supplied by the colleges and universities were taken from the *hep 1984 Higher Education Directory.*

Most of the data supplied by the participating institutions since 1965-66 have been stored on magnetic tape. They are therefore available for supplementary studies of educational philanthropy.

A number of institutions that had participated in the past were unable to revise their gift accounting and reporting procedures in sufficient time to reply to this year's restructured survey. A number of other institutions were not able to supply all of the data requested, but provided as much as they could. We are grateful to all of these institutions for their efforts and expressions of cooperation.

Survey Participation, 1983-84

	Four-Year Colleges and Universities	Two-Year Colleges	Independent Precollege Schools	Total
Invited to participate	1,820	1,006	910	3,736
Completed and tabulated questionnaires	982	136	451	1,569
Not tabulated:				
Unable to participate	3	2	3	8
No support	2	31	—	33
Reporting too late or in totals only	8	2	2	12
Total response	995	171	456	1,622
Response rate	54%	17%	50%	43%
Total amount tabulated	$4,642,891,010	$35,246,422	$280,119,367	$4,958,256,799
Too late or in total only	$ 62,328,376	$ 353,679	$ 1,319,799	$ 64,001,854
Total amount reported	$4,705,219,386	$35,600,101	$281,439,166	$5,022,258,653

Additional Respondents—Voluntary Support of Education, 1983-84

INSTITUTIONS NOT TABULATED
(Reporting Late or in Grand Total Only)

FOUR-YEAR COLLEGES & UNIVERSITIES (8)	
Bennington Col. (VT)	$ 2,105,548
Emporia St. Univ. (KS)	1,150,736
Free Will Bapt. Bible Col. (TN)	754,807
Illinois St. Univ. (IL)	1,196,211
North Carolina, Univ. of-Chapel Hill (NC)	24,926,151
Oklahoma, Univ. of (OK)	13,300,000
St. Louis Cons. & Schs. for the Arts (MO)	1,193,523
Yeshiva Univ. (NY)	17,700,000
TWO-YEAR COLLEGES (2)	
Lon Morris Col. (TX)	329,479
Northern Essex CC (MA)	24,200
INDEPENDENT PRECOLLEGE SCHOOLS (2)	
Breck Sch. (MN)	676,023
Procter Acad. (NH)	643,776

INSTITUTIONS UNABLE TO PARTICIPATE

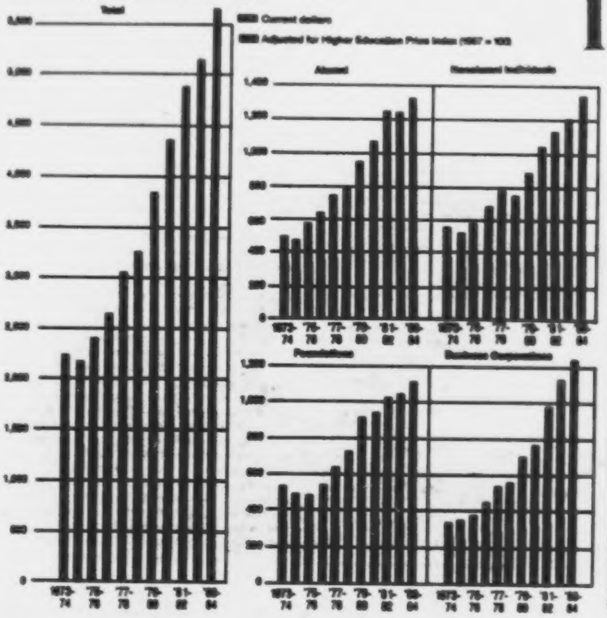
FOUR-YEAR COLLEGES & UNIVERSITIES (3)
Gratz Col. (PA)
Osteopathic Med. & Health Scs., Univ. of (IA)
Regis Col. (CN)

TWO-YEAR COLLEGES (2)
Highland CC (IL)
Westchester CC (NY)

INDEPENDENT PRECOLLEGE SCHOOLS (3)
Episcopal Day Sch. (TN)
St. Gertrude HS (VA)
Storm King Sch. (NY)

To all those who filled out the questionnaires, to the institutions they represent, and to the cooperating associations in the educational community, CASE, CFAE and NAIS express their gratitude.

Chart 1. Estimated Voluntary Support of Colleges and Universities by Major Sources and in Total (millions of dollars)



I

National Estimates

- Total contributions to higher education increased by $440 million in 1983-84 to an estimated $5.6 billion. The 8.5 percent increase bettered the 6.2 percent rise in 1982-83 and was the ninth successive annual rise in voluntary support.
- Corporate gifts rose 14.3 percent, a greater increase than from any other donor group.
- Gifts from nonalumni/ae individuals edged past those from alumni/ae for the first time since 1977-78.
- Gifts for current operations rose faster than those for capital purposes, growing by 9.0 percent.

Voluntary support of colleges and universities increased in 1983-84 for the ninth year in a row. At $5.6 billion in 1983-84, voluntary support has more than doubled since 1974-75, the last year in which gifts declined.

The 8.5 percent rise in voluntary support was more than double the inflation rate of 3.7 percent as measured by the Consumer Price Index (CPI) and was greater than the 5.4 percent rise in the cost of goods and services purchased by higher education institutions, as measured by the Higher Education Price Index (HEPI). (*See Chart I and Table I*).

By Source

Gifts from nonalumni/ae individuals, which topped those from alumni/ae for the first time since 1977-78, accounted for 23.5 percent of total voluntary support. Corporate support continued its meteoric rise, registering a 14.3 percent gain over the 1982-83 total and providing 22.7 percent of all gifts. This is the fifth consecutive year that corporations have increased their support of colleges and universities by double-digit percentages. Foundation gifts comprised a slightly smaller share of total voluntary support, having dropped from 23.9 percent of all gifts ten years ago to 10.3 percent in 1983-84.

Some of the rise in corporate gifts resulted from a surge in gifts of products manufactured by the corporations. These gifts were encouraged by the Economic Recovery Tax Act of 1981 (ERTA), which provided enhanced tax deductions for products donated to colleges for use in research and-training in research. In the 1983-84 survey 1,118 colleges reported receiving gifts of company products valued at $117 million, almost twice the $59 million reported in 1982-83. Corporations also gave almost $43 million in other kinds of physical property, such as used equipment, vehicles, land and other surplus items.

Gifts from alumni/ae resumed their upward climb with a 5.4 percent increase after a small decline in 1982-83.

Religious organizations registered a 7.8 percent decrease in support in 1983-84. The drop in the importance of gifts from religious organizations is consistent with a trend seen in the last 25 years. Religious groups provided 10.3 percent of all private gifts in 1958-59; they provided 3.4 percent in 1983-84. Many of the private colleges that were once either church related or church controlled have since become independent and thus rely less on support from their religious affiliation than in the recent past.

The one-year changes in giving between 1982-83 and 1983-84 are consistent with patterns seen in the last five survey years. Corporate gifts have more than doubled; gifts from nonalumni/ae individuals have grown at a faster rate than gifts from both alumni/ae and foundations. Support from religious organizations has grown only slightly. Gifts from all donor groups except religious organizations have outpaced the rises in both the CPI and the HEPI.

By Purpose

The questions on the survey about donor purposes were changed considerably in 1983-84, so that the data collected were not comparable with those collected in previous years. The only estimates about donor purposes possible in 1983-84 are for gifts for current operations and for capital purposes. As more data are accumulated in future surveys, detailed estimates about changes in the purposes for which gifts are made will again be possible.

Just over three fifths of voluntary support was designated for current operations in 1983-84. Prior to 1969-70 less than half of all private gifts were channeled into current operations. In the first half of the 1970s, slightly more than half of the gift dollars went to current operations; since then more than 60 percent of the funds raised have been designated for current operations. Increased fund raising by publicly supported institutions is responsible for some of this reversal. More than two thirds of the funds public institutions raise are for current operations rather than for capital purposes.

Table 1. Estimated Voluntary Support, by Source and Purpose (millions of dollars)

	1978-79	1982-83	1983-84	Percent Change, 1983-84		
				vs. 1982-83	vs. 1978-79	vs. 1978-79 adj. for HEPI
TOTAL VOLUNTARY SUPPORT	$3,230	$5,160	$5,600	+ 8.5	+ 73.4	+ 15.6
Sources						
Alumni	$ 785	$1,237	$1,305	+ 5.4	+ 66.2	+ 10.8
Nonalumni Individuals	738	1,190	1,319	+ 10.8	+ 78.8	+ 19.2
Business Corporations	555	1,112	1,271	+ 14.3	+ 129.0	+ 52.7
Foundations	701	1,018	1,081	+ 6.2	+ 54.2	+ 2.8
Religious Organizations	161	206	190	− 7.8	+ 18.0	− 21.4
Other	291	397	437	+ 10.1	+ 50.2	—
Purposes						
Current Operations	$2,010	$3,125	$3,405	+ 9.0	+ 69.4	+ 12.9
Capital Purposes	1,220	2,035	2,195	+ 7.9	+ 79.9	+ 20.1
Price Indices (1967 = 100)						
Consumer (CPI)	206.4	293.8	304.9	+ 3.7	+ 47.7	
Higher Education (HEPI)	216.9	308.8	325.4	+ 5.4	+ 50.0	

Institutional Expenditures and Voluntary Support

Voluntary support is only one factor in the economic situation of colleges and universities. College administrators must be concerned with the impact of enrollment changes and inflation on total expenditures. *Table 2* examines these factors and presents some good news.

The long projected enrollment declines have not yet occurred, so that the student population has remained fairly constant for the last ten years. Inflation, as measured by both the CPI and the HEPI, has slowed since 1980-81, thus lessening the pressures of the previous

Table 2. Voluntary Support in Relation to Enrollment, Inflation and Institutional Expenditures

Year	Total Enrollment (thousands)	Price Indices (1967 = 100) CPI	Price Indices (1967 = 100) HEPI	Institutional Expenditures Total (billions)	Institutional Expenditures Per Student (Current)	Institutional Expenditures Per Student (CPI)	Estimated Voluntary Support Total (millions)	Estimated Voluntary Support Per Student (Current)	Estimated Voluntary Support Per Student (CPI)	As % of Institutional Expenditures
1949-50	2,659	71.7	n.a.	$ 2.5	$ 940	$1,310	$ 240	$ 90	$126	9.6
1965-66	5,967	95.9	95.0	15.2	2,547	2,655	1,440	241	251	9.4
1970-71	8,581	119.8	129.6	26.9	3,130	2,630	1,860	217	182	6.9
1975-76	11,185	165.9	177.2	42.6	3,809	2,296	2,410	215	130	5.7
1980-81	12,097	259.6	263.9	70.3	5,810	2,240	4,230	350	135	6.0
1983-84	12,465	304.9	325.4	89.6	7,200	2,350	5,600	449	147	6.2
Average Annual Percentage Change										
1949-50 to 1965-66	5.2	1.8	n.a.	11.9	6.4	4.5	11.8	6.4	4.4	
1965-66 to 1970-71	7.5	4.4	6.2	12.1	4.2	−0.1	5.3	−2.1	−6.1	
1970-71 to 1975-76	5.4	6.6	6.4	9.6	4.0	−2.7	5.3	−0.2	−6.6	
1975-76 to 1980-81	1.6	9.4	8.3	10.6	8.8	−0.4	11.9	10.2	0.8	
1980-81 to 1983-84	1.0	5.4	7.2	8.4	7.4	1.6	9.8	8.7	2.9	

decade on college budgets. Institutional expenditures continued to grow in the 1980s, but were not driven as much by inflation in that period as in the 1960s and 1970s. Colleges turned their attention to several areas that had been neglected during the years of high inflation: faculty salaries, libraries, laboratories and instructional facilities, plant maintenance and repair. As a result expenditures per student, which can serve as one measure of educational quality, increased between 1980-81 and 1983-84 both in current dollars and as adjusted for inflation. These improvements often were funded by tuition increases.

Voluntary support grew at faster rates than institutional expenditures between 1975-76 and 1983-84 and therefore provided an increasing share of college budgets. Still, gifts have not assumed the same degree of importance in college and university budgets as in the 1950s and 1960s.

The future will continue to present difficulties for institutional budgets. Uncertainties about the availability of loan funds, together with the threat of higher interest costs, may make some potential students put off going to college at the present time. Critics are now questioning the effectiveness of much of higher education, putting additional pressures on college administrators and faculties to improve the quality of the instruction offered and thus indirectly suggesting even higher tuition rises.

That contributions have continued to increase and now outpace inflation is evidence that higher education has been able to plead its case well in the past. With continuing efforts at self-improvement where necessary, it should be able to continue to do so in the future.

II Survey Results

- The 1,110 respondents reported gifts of $4.60 billion in 1983-84, an average of $4.104 million per institution.
- The 989 institutions in both the 1982-83 and the 1983-84 surveys reported an increase in total support of 9.4 percent. Gifts to doctoral institutions grew by 12.3 percent, to all public institutions by 10.3 percent and to all private institutions by 9.0 percent. Corporate support rose 13.8 percent.
- Gifts of property totaled $279.5 million, including $106.87 million in company products, $42.90 million in corporate gifts of other property and $129.67 million of in-kind items from all other sources.
- Corporate support from matching gifts declined by 2.5 percent to a total of $75.8 million, but the average match reached a record $239.82.
- Alumna/ae gifts to the annual fund grew by 5.4 percent; the average gift was a record $113.40, and a record 20.4 percent of all alumna/ae solicited gave.
- Almost three fifths of all contributions were made for current operations.
- Three quarters of all gifts carried restrictions about their use.

This section of the survey report uses the actual figures reported by the participants to provide two kinds of analysis: 1) details of the support raised during the year by the respondents—from whom, by whom and for what purpose; and 2) changes from year to year and over longer periods of time.

Analyzing results over time presents difficulties not encountered in analyses of a single year's results. Many institutions respond to the questionnaire every year, but some participate only sporadically. Meaningful comparisons between years require identical groups of respondents—a "core" group of institutions that report for each of the years compared. This group is always smaller than the total number of respondents in any single year.

The 1983-84 survey has additional complications. It was restructured to reflect the sources and purposes for reporting gift income as defined in *Management Reporting Standards for Educational Institutions: Fund Raising and Related Activities*, published by the Council for Advancement and Support of Education and the National Association of College and University Business Officers. The questionnaire therefore asked for almost twice as many details about contributions as in the past; a donor group—parents—was added; and the donor purposes were changed drastically to reflect more accurately fund-raising activities and university accounting procedures. These changes made comparison over time even more difficult than in the past, but in the long run will provide more useful data.

In addition, the participating institutions are now grouped according to the National Center for Education Statistics (NCES) classification structure. This system places institutions into homogeneous groupings, enabling more meaningful comparisons than in the past. Also, the data gathered in this survey can now be utilized in connection with other data bases that use the NCES structure.

NCES defines five major categories of institutions:

1. *Doctorate-granting institutions:* Universities that are very active at the doctoral level, granting a minimum of 30 doctorates in 3 or more doctoral-level

programs, including first-professional-level medical degrees.

2. *Comprehensive institutions:* Colleges and universities that have strong postbaccalaureate programs, but not significant doctoral-level activity, granting a minimum of 30 postbaccalaureate degrees (including master's and some doctorate and first-professional degrees).
3. *General baccalaureate institutions:* Those whose primary emphasis is on general undergraduate, baccalaureate education. They grant baccalaureate degrees in 3 or more baccalaureate programs or in interdisciplinary studies (with over 75 percent of their degrees at the baccalaureate level or above) and fewer than 30 postbaccalaureate degrees.
4. *Professional and specialized institutions:* Those that are baccalaureate and postbaccalaureate institutions with a programmatic emphasis in one area, usually a professional field such as business, engineering, medicine, theology or art.
5. *Two-year institutions:* Schools that confer more than 75 percent of their degrees or awards for 2 years of work and less than 25 percent at the baccalaureate or postbaccalaureate level. (Institutions with a two-year upper-division program do not fall in this category, since they offer the baccalaureate.)

The institutions in each of these categories are further divided by their control—that is, private and independent or publicly controlled by local, state or federal governments.

The Recipients

A slightly smaller number of institutions participated in the survey in 1983-84, perhaps because of the increased difficulty in completing the questionnaire. The 1,118 respondents (21 fewer than in 1982-83) reported good news, however, recording an overall increase of $306.6 million over total gifts in 1982-83 (see *Table 2*).

The two groups of doctoral institutions—public and private—each received more than $1 billion in gifts. The $2.8 billion recorded by these 150 doctoral institutions represented 60.7 percent of the total gifts to all respondents. Public institutions participated to a larger degree in the 1983-84 survey than in any previous year. Twenty-eight percent of the responding four-year universities and colleges were public, and they raised 32.4 percent of all the funds. Ten years ago 24 percent of the respondents

Table 2: Voluntary Support by Type of Institution (NCES classification) (000 omitted)

Type of Institution	1982-83 No.	Amount	Average per Institution	1983-84 No.	Amount	Average per Institution	% Change in Average	Core Group % Change in Total Support	No.
DOCTORAL									
Private	57	$1,436,537	$25,202	59	$1,504,284	$25,497	+13.0	+12.3	55
Public	90	1,124,749	12,497	94	1,243,743	13,231	+ 5.9	+12.3	93
COMPREHENSIVE									
Private	133	429,606	3,230	135	487,018	3,606	+11.7	+12.5	127
Public	117	125,036	1,069	124	118,065	952	−10.9	− 3.4	96
GENERAL BACCALAUREATE									
Private	434	872,084	2,009	411	861,640	2,096	+ 4.3	+ 2.8	374
Public	41	21,720	530	39	25,312	649	+22.4	+26.3	29
SPECIALIZED									
Private	119	213,617	1,795	105	194,874	1,856	+ 3.4	+ 1.6	79
Public	20	109,512	5,476	18	116,906	6,495	+18.6	+ 2.9	16
TOTAL FOUR-YEAR									
Private	743	$2,951,845	$ 3,973	707	$3,138,535	$ 4,440	+11.8	+ 9.0	635
Public	269	1,391,080	5,153	275	1,504,056	5,469	+ 6.1	+10.4	224
TWO-YEAR									
Private	43	24,798	577	42	20,610	491	−14.9	+ 5.4	31
Public	84	13,941	165	94	14,637	156	− 5.4	+ 6.5	38
All Private	786	$2,976,637	$ 3,787	749	$3,159,445	$ 4,218	+11.4	+ 9.0	666
All Public	353	1,394,991	3,963	369	1,518,693	4,116	+ 3.9	+10.3	262
GRAND TOTAL	1,139	$4,371,499	$ 3,841	1,118	$4,678,137	$ 4,184	+ 8.9	+ 9.4	928

Table 2A. Voluntary Support by Type of Institution (old CFAE classification) (000 omitted)

Type of Institution	1982-83* No.	Amount	Average per Institution	1983-84 No.	Amount	Average per Institution	% Change in Average	Core Group % Change in Total Support	No.
Private Universities	73	$1,530,598	$20,967	71	$1,683,947	$23,718	+13.1	+12.4	71
Private Men's Colleges	9	20,439	2,271	6	16,147	2,691	+18.4	+ 2.4	6
Private Women's Colleges	77	155,421	2,019	72	156,995	2,181	+ 8.1	+ 3.4	70
Private Coeducational Colleges	496	1,079,190	2,176	472	1,095,201	2,320	+ 6.6	+ 4.3	429
Professional & Specialized Schools	90	185,810	2,065	88	209,136	2,377	+15.1	+15.6	61
Total Private Four-Year	745	$2,971,458	$ 3,989	709	$3,161,427	$ 4,459	+11.8	+ 9.1	637
Public Four-Year Institutions	266**	1,362,455	5,122	273	1,481,464	5,427	+ 6.0	+10.2	222
Total Four-Year Institutions	1,011	$4,333,913	$ 4,287	982	$4,642,891	$ 4,728	+10.3	+ 9.4	859
Two-Year Institutions	127	37,586	297	136	35,246	261	−12.1	+ 5.8	69
GRAND TOTAL	1,139	$4,371,499	$ 3,841	1,118	$4,678,137	$ 4,184	+ 8.9	+ 9.4	928

*Figures differ slightly from those published in the 1982-83 survey report because of institutional reclassifications. Details do not always add up to totals because of rounding.

**Differs from the number shown in Table 2 because of different classification criteria in the two systems.

were public institutions, and they raised 22 percent of the gifts.

Comparisons of the total amounts reported by all institutions in 1982-83 and 1983-84 can be misleading because of differences in the number and characteristics of the respondents each year. Calculating average support per institution in each class partially corrects for these disparities. The results are shown in *Table 3*.

In contrast to the last several surveys, when support for public institutions surged, it was the private institutions in 1983-84 — notably the doctoral and comprehensive colleges — that reported double-digit increases in average support per institution. The only groups of public institutions reporting such increases in average support in this survey were the general baccalaureate and the specialized institutions, both of which are very small. Generally, average support for the private institutions ranged between two and three times the average for the public institutions. The only exception was the public specialized institutions, many of which are medical and engineering schools, which raised three times the average for the private specialized institutions.

The changes reported by the "core" institutions in general follow the change patterns of the averages for the total group of respondents. Analysis of the two groups that differ the most — the public doctoral and the public specialized — reveal some interesting factors. A 22.1 percent increase in corporate support and a 19.2 percent rise in gifts from nonalumni/ae individuals fueled the 12.3 percent increase in support for the public doctoral institutions. An 8.2 percent decrease in gifts from nonalumni/ae individuals, together with minimal increases in corporate and foundation support, were responsible for the small growth in total support for the "core" public specialized institutions. A doubling of gifts from nonalumni/ae individuals, coupled with a 58.1 percent rise in foundation support and a 30.9 percent growth in corporate grants, produced the large increase in support of the public baccalaureate institutions.

Comparison of the results in Table 3 with those shown in Table 3A, which shows the responding institutions

Table 4. Percentage Changes in Average Voluntary Support per Institution by Source, 1982-83 to 1983-84

Source	All Institutions Reporting Average 1982-83	 Average 1983-84	 % Change in Average	Core Group % Change in Average
Alumni	$ 920,198 (24.0)	$ 974,575 (23.3)	+ 5.9	+ 5.9
Nonalumni Individuals	886,323 (23.1)	978,931 (23.4)	+ 10.4	+ 13.1
Foundations	758,520 (19.7)	813,655 (19.4)	+ 7.3	+ 6.3
Corporations	827,723 (21.5)	948,515 (22.7)	+ 14.6	+ 13.8
Religious Organizations	153,280 (4.0)	141,106 (3.4)	− 7.9	+ 8.2
Other	295,351 (7.7)	327,599 (7.8)	+ 10.9	+ 6.2
GRAND TOTAL	$3,841,396 (100.0)	$4,184,381 (100.0)	+ 8.9	+ 9.4
No. Institutions Reporting	1,139	1,118		929

(Figures in parentheses show percent of total in each column.)

Table 5. Alumni/ae Support of Colleges and Universities and the Annual Fund

Year	Institutions Reporting	Number of Alumni/ae Donors to Annual Fund	Alumni/ae Gifts to Annual Fund	Average Gift	Solicitation Effectiveness	Total Alumni/ae Support
1973-74	985	2,277,580	$157,214,301	$ 69.03	17.4%	$ 398,965,299
1974-75	996	2,371,331	165,955,732	69.98	17.4	377,179,344
1975-76	981	2,527,967	185,436,651	73.35	17.6	461,090,565
1976-77	1,008	2,659,313	210,130,479	79.02	17.5	500,125,565
1977-78	1,005	2,695,690	223,633,074	82.98	17.6	552,621,499
1978-79	972	2,763,127	266,914,036	96.60	17.9	620,347,430
1979-80	1,019	3,015,084	288,247,120	95.25	18.1	725,540,650
1980-81	969	3,177,233	311,858,940	98.15	18.6	921,135,159
1981-82	1,101	3,582,677	373,194,415	104.16	18.9	1,051,907,044
1982-83	1,139	3,706,905	414,202,314	110.17*	19.7*	1,047,173,983
1983-84	1,118	3,830,417	436,545,179	113.40*	20.4*	1,088,573,049

*Size of average gift and solicitation effectiveness based only on responses containing all data.

classified as in past surveys, illustrates the advantages of the NCES classification. According to the results in *Table 3A*, for example, support for all the four-year public institutions increased by 6.0 percent in 1983-84. *Table 3* reveals, however, that this single percentage masks wide variations in the changes reported by the various groups of public institutions, ranging from a decrease of 10.9 percent to increases of 5.9, 18.6 and 22.4 percent. Similarly, the 12.1 percent decrease registered by all two-year institutions results from a much larger decrease for the private than for the public institutions.

The Donors

As growth in corporate support has outpaced rises in support from other donor groups in the last few years, the average corporate support per institution now more nearly equals the average support from alumni/ae and nonalumni/ae individuals. Each of these three major donor groups provided over 22 percent of all voluntary support in 1983-84, as can be seen in Table 4.

Average support per institution from nonalumni/ae individuals surpassed average support from alumni/ae in 1983-84 for the first time since 1977-78. Private institutions received over 70 percent of nonalumni/ae gifts and more than three quarters of alumni/ae donations. Corporations, on the other hand, divided their grants almost equally between public and private institutions, with the private colleges receiving only a slightly larger share in 1983-84. The division of corporate support between private and public institutions has changed substantially in the last 25 years. In 1958-59 77.3 percent of corporate grants were made to private institutions. The allocation has dropped steadily since then, reaching the 52.8 percent share reported in this survey. Foundations, on the other hand, have apportioned their grants consistently over the years, channeling about 70 percent to private institutions.

The wide variation in change patterns between average gifts from religious organizations for all respondents in 1982-83 and 1983-84 and for the "core" group of institutions responding in both years vividly illustrates the problems caused by differences in the experiences and characteristics of survey participants in the two samples.

Table 6. Alumni/ae Support of Annual Fund by Type of Institution, 1982-83 and 1983-84

Type of Institution	1982-83 Solicitation Effectiveness	1982-83 Average Gift	1983-84 Solicitation Effectiveness	1983-84 Average Gift	% Change Average Gift
DOCTORAL					
Private	27.9%	$165.98	29.5%	$178.38	+ 7.5
Public	14.9	88.11	15.7	83.47	− 5.3
COMPREHENSIVE					
Private	21.8	99.37	22.1	107.55	+ 8.2
Public	10.8	42.61	12.2	42.71	+ 0.2
GENERAL BACCALAUREATE					
Private	26.5	109.02	27.4	112.06	+ 2.8
Public	19.5	56.26	19.4	62.12	+10.4
SPECIALIZED					
Private	21.9	95.54	21.5	101.62	+ 6.4
Public	22.4	72.59	24.6	91.10	+25.5
TOTAL FOUR-YEAR					
Private	25.0%	$127.92	26.1%	$135.83	+ 6.2
Public	14.2	78.70	15.2	75.24	− 4.4
TWO-YEAR					
Private	14.9	66.50	12.7	60.30	− 9.3
Public	5.0	38.34	6.0	157.00*	*
All Private	25.4%	$127.20	25.9%	$135.06	+ 6.2
All Public	14.1	78.58	15.1	75.60	− 3.8
GRAND TOTAL	19.7%	$110.17	20.4%	$113.40	+ 2.9

*One institution reported a single gift of $250,000 along with several other large gifts, as part of a very successful campaign. Excluding these extraordinary data, the average gift would be $20.37 and the year-to-year change − 43.9 percent.

Special Forms of Giving

Respondents were asked to provide details about several ways in which gifts were made to them. The *annual fund* has long been a technique for gaining alumni/ae support. *Bequests* and various forms of *deferred gifts*, such as charitable remainder trusts, pooled income funds and gift annuities, are estate planning methods encouraged by colleges and universities. More than 1,000 corporations have established *matching-gift programs* that double, triple or even quadruple the value of their employees' gifts to higher education. Gifts of *company products*, encouraged by the Economic Recovery Tax Act of 1981, and of other physical property are now popular sources of special gifts to colleges and universities.

Annual Funds

Table 5 presents data about annual funds since 1973-74. Although the number of institutions responding to the survey has varied over the years, the number of alumni/ae donors to the annual fund, the total value of their gifts and the average gift have grown steadily each year. The 20.4 percent alumni/ae response rate recorded in 1983-84 is an all-time high. The annual fund has garnered about 40 percent of all alumni/ae gifts consistently over the years.

Alumni/ae of various classes of institution respond differently to solicitations for the annual fund, as can be seen in Table 6. Historically, private colleges and universities have relied more heavily on annual-fund drives than have public institutions, and four-year institutions conduct these drives more often than do the two-year institutions. The average gift and the response rate of the alumni/ae are therefore generally larger at the private colleges than at the public colleges.

Bequests and Deferred Gifts

Bequests and deferred gifts accounted for 27.3 percent of total support from all individuals in 1983-84. Prior to 1979-80 bequests and deferred gifts averaged about 35 percent of all gifts from individuals. Since then they have averaged about 30 percent. They tend to be somewhat "lumpy," however, because of the unpredictability of very large bequests.

Matching Gifts

Corporate funds matching employee gifts to higher education institutions have been growing in importance to the colleges. In 1966-67, when this survey started collecting matching-gift data, grants from this source were 2.0 percent of all corporate grants. They reached 8.6 percent in 1982-83 and apparently retreated slightly in 1983-84 to 7.4 percent. This figure may not be completely representative, however, since a number of institutions which reported matching gifts of over $3 million in 1982-83 did not furnish matching-gift data in 1983-84. The importance of matching-gift monies varies considerably according to the type of institution (see Table 7). As with the annual fund, matched gifts are larger and generally a more important source of funds for the private institutions than for the public institutions. Matched gifts also represent a much larger proportion of corporate grants to the private liberal arts colleges than to other types of institutions.

Table 7. Support through Matching-Gift Programs and Total Corporate Support by Type of Institution, 1983-84

Type of Institution	Amount through Matched Gifts	Size of Average Match	Total Corporate Support	Matching Gifts as a Percent of Total Corporate Support
DOCTORAL				
Private	$24,107,600	$268.74	$ 351,617,196	6.9
Public	15,588,400	190.95	424,534,750	3.7
COMPREHENSIVE				
Private	10,309,670	228.57	71,647,093	14.4
Public	1,987,030	170.85	34,923,292	5.7
GENERAL BACCALAUREATE				
Private	21,495,300	292.63	93,296,579	23.0
Public	334,300	299.53	6,024,149	5.6
SPECIALIZED				
Private	3,411,894	183.34	40,521,925	8.4
Public	1,192,415	170.22	30,335,229	3.9
TOTAL FOUR-YEAR				
Private	$59,327,183	$250.42	$ 557,092,637	10.7
Public	19,083,205	189.09	495,317,407	3.9
TWO-YEAR				
Private	308,540	155.53	2,614,094	11.8
Public	37,495	234.30	5,225,732	0.7
All Private	$59,635,663	$250.34	$ 559,696,641	10.7
All Public	19,120,693	189.76	500,743,139	3.8
GRAND TOTAL	$78,756,356*	$228.92	$1,060,439,780	7.4
1982-83 GRAND TOTALS	$80,902,194	$216.72	$ 941,356,901	8.6

*This figure may not be completely representative, since a number of institutions, which reported matching gifts of over $3 million in 1982-83, did not furnish matching-gift data in 1983-84.

Company Products and Other Property

Data on gifts of company products and other property were sought for the first time in the 1982-83 survey, and more details were collected in the 1983-84 survey. The results are presented in Table 8. Gifts-in-kind from all sources amounted to almost $290 million, or 6.0 percent of total voluntary support in 1983-84. They consisted of $116.87 million of company products, $42.95 million of other property from corporations and $129.67 million of in-kind items from all other sources. These totals do not represent the full value of all these gifts, however, since some institutions book in-kind gifts at a nominal value of $1 each.

Reported gifts of company products almost doubled in 1983-84, perhaps in part because of better institutional record keeping and reporting procedures. Timing could also account for some of the increase. A grant commitment may be made in one academic year, but the property not received and reported until the following academic year. Reports about these gifts can therefore vary widely from year to year.

Gifts of company products, together with gifts of other property from corporations, made up 15.1 percent of all corporate support. The average size and importance of such gifts to the colleges again varied according to the type of institution. More than three quarters of all company product gifts and two fifths of corporate gifts of other property went to doctoral institutions. In several instances larger amounts of property were given to public institutions than to private institutions.

Colleges usually report product gifts at market value. The tax deduction taken by the donor corporation, however, is less. It is either manufacturing cost or half the difference between manufacturing cost and market value, if the donated product is for research or training in research. Consequently, college reports of company product gifts will be higher than corporate reports.

Gifts of property from noncorporate sources amounted to 3.2 percent of gifts from all sources other than corporations. The private comprehensive and general baccalaureate institutions got more property gifts from noncorporate sources than from corporate sources. The private doctoral institutions received more property from corporations than from other sources. The public doctoral and comprehensive institutions together received the lion's share of property gifts to public institutions from other sources — 91 percent. Overall, donor groups other than corporations split their property gifts almost evenly between public and private institutions.

The Purposes

Gifts for current operations accounted for almost three fifths of all voluntary support in 1983-84, and more than two thirds of those gifts were channeled into specific uses, as shown in Table 8.

Respondents were asked to provide details about the restricted uses for both current-fund and capital gifts. Table 10 presents the results for those institutions that could provide the data. The amounts reported represent 93.8 percent of all gifts for current operations and 97.1 percent of all funds given for capital purposes. Both are large enough shares to provide valuable insights into how donors want their gifts used.

Research, particularly for current operations, was the most popular object of restricted gifts, with 25.3 percent. Student aid was next, receiving just over one fifth of the

Table 5. Gifts of Property by Type of Institution, 1983-84

Type of Institution	Company Products: Total Amount	Company Products: Average Size of Gift	Other Property from Corporations: Total Amount	Other Property from Corporations: Average Size of Gift	Other Property from All Other Sources: Total Amount	Other Property from All Other Sources: Average Size of Gift	Grand Total
DOCTORAL							
Private	$ 41,282,250	$ 98,619	$ 2,225,991	$11,430	$ 25,049,340	$ 3,236	$ 69,580,380
Public	48,144,153	30,452	13,503,300	14,661	44,370,498	4,608	106,017,951
COMPREHENSIVE							
Private	3,036,190	9,783	4,432,630	4,772	13,757,031	3,827	21,225,990
Public	5,382,693	8,094	7,905,513	8,348	9,074,068	4,222	22,362,274
GENERAL BACCALAUREATE							
Private	4,435,571	5,386	6,675,518	11,111	14,580,490	1,938	25,690,579
Public	1,102,661	5,967	1,300,282	6,374	2,964,082	4,586	5,167,025
SPECIALIZED							
Private	5,744,547	20,459	2,600,903	13,270	1,377,014	2,387	9,722,464
Public	4,586,038	148,385	631,060	16,181	690,763	4,437	5,908,864
TOTAL FOUR-YEAR							
Private	$ 54,498,567	$ 25,980	$15,937,981	$ 8,202	$ 55,758,763	$ 2,947	$126,196,301
Public	58,320,536	24,050	23,340,104	11,019	58,986,411	4,520	141,538,114
TWO-YEAR							
Private	135,585	2,600	74,586	1,307	5,391,158	3,940	5,600,979
Public	1,905,060	10,087	1,707,198	7,000	1,561,289	2,039	5,173,569
All Private	$ 54,634,086	$ 26,170	$16,012,200	$ 8,082	$ 61,143,030	$ 2,600	$131,790,290
All Public	60,233,580	22,050	25,047,300	11,504	59,536,079	4,640	147,711,643
GRAND TOTAL	$116,867,651	$25,437	$41,080,612	$ 9,770	$118,674,617	$ 3,480	$279,501,980
1982-83	$ 99,543,493			$ 95,460,254			$157,463,738

Table 6. Percentage Changes in Average Voluntary Support per Institution by Purpose, 1982-83 to 1983-84

	All Institutions Reporting: Average 1982-83	All Institutions Reporting: Average 1983-84	All Institutions Reporting: % Change in Average	Core Group: % Change in Average
CURRENT OPERATIONS				
Unrestricted	$ 831,544	$ 779,383	− 6.3	− 3.9
Restricted	1,388,427	1,641,597	+18.3	+17.4
TOTAL	$2,219,971	$2,420,980	+ 9.1	+ 8.8
CAPITAL PURPOSES	$1,621,319	$1,763,408	+ 8.8	+ 8.9
GRAND TOTAL	$3,841,290	$4,184,391	+ 8.9	+ 8.4
No. Institutions Reporting	1,118	1,118		958

restricted monies. Other restricted but unspecified purposes received almost a quarter of the restricted gifts.

The ways in which gifts were restricted in both public and private institutions were remarkably similar.

Size of Gifts

Another first in the 1983-84 survey was the collection of data on gifts from individuals for current operations that were under $5,000 or of $5,000 or more. Participants provided these breakdowns for amounts equaling almost three fourths of all gifts from individuals for current operations. The results are presented in *Table 11*.

Gifts of $5,000 or more numbered just 0.4 percent of these gifts, but provided more dollars than did the smaller gifts (twice as much money for the private doctoral institutions). In all other groups except the public doctoral and public two-year institutions, the smaller gifts provided more total funds than the large gifts.

Table 10. Support with Restrictions as to Use for Current Operations and for Endowment, for Institutions Reporting these Data, 1983-84

Donor Purpose	Current Operations–Restricted Purpose			Endowment–Restricted Use of Income			Grand Total
	Private	Public	Total	Private	Public	Total	
Academic Divisions	$146,053 (16.4)	$131,838 (15.8)	$ 278,401 (16.2)	$ 62,318 (10.3)	$ 23,980 (11.2)	$ 86,215 (10.6)	$ 364,709 (14.6)
Faculty and Staff Compensation	38,997 (5.6)	10,882 (2.0)	49,930 (5.0)	117,231 (19.4)	40,878 (19.3)	158,109 (19.4)	208,040 (8.1)
Research	303,932 (33.3)	289,507 (38.8)	593,439 (34.5)	24,489 (4.1)	23,905 (11.2)	48,394 (6.0)	641,713 (25.3)
Public Service and Extension	7,201 (0.8)	40,128 (4.8)	47,329 (2.7)	4,016 (0.7)	1,449 (0.7)	5,464 (0.7)	52,793 (2.1)
Library	14,891 (1.7)	9,610 (1.2)	24,501 (1.4)	18,570 (3.1)	3,744 (1.8)	22,314 (2.7)	46,815 (1.8)
Operation and Maintenance of Physical Plant	39,473 (4.1)	9,770 (1.2)	46,243 (2.7)	16,203 (2.7)	6,500 (3.0)	22,704 (2.8)	69,039 (2.7)
Student Financial Aid	145,434 (16.0)	114,314 (13.9)	259,748 (15.2)	197,140 (32.7)	63,588 (30.0)	260,728 (32.0)	522,468 (20.6)
Other Restricted Purposes	244,465 (27.3)	179,190 (21.3)	420,675 (24.4)	162,979 (27.0)	48,070 (22.7)	211,039 (25.9)	631,734 (24.9)
TOTAL	$894,399	$837,616	$1,721,904	$602,944	$212,025	$814,970	$2,536,904
No. Institutions Reporting	608	389	994	509	223	785	
Total as % of Restricted Support Reported by All Institutions	94.4	93.2	93.8	86.8	86.2	87.1	91.6

(Figures in parentheses show percent of total in each column; dollars in thousands; details do not always add up to totals because of rounding.)

Table 11. Gifts from Individuals for Current Operations Under $5,000 and $5,000 or More, by Type of Institution, 1983-84

	Gifts Under $5,000		Gifts of $5,000 or More	
	Amount	No. of Gifts	Amount	No. of Gifts
DOCTORAL				
Private	$ 95,596,302	720,911	$205,420,713	4,701
Public	71,833,481	743,700	91,897,887	3,089
COMPREHENSIVE				
Private	40,527,863	461,299	39,591,343	1,395
Public	19,167,053	299,549	4,440,799	277
GENERAL BACCALAUREATE				
Private	108,463,053	979,420	68,289,398	4,738
Public	5,072,590	99,308	425,309	44
SPECIALIZED				
Private	31,150,848	187,921	9,978,316	989
Public	6,811,329	43,154	4,455,087	371
TOTAL 4-YEAR				
Private	$283,485,564	3,287,577	$369,387,990	11,890
Public	101,295,092	1,109,889	91,129,080	2,913
TWO-YEAR				
Private	2,762,619	31,744	654,851	61
Public	608,005	7,473	785,424	52
All Private	$289,248,513	3,309,321	$335,042,821	11,951
All Public	101,911,097	1,116,471	91,945,314	3,938
GRAND TOTAL	$388,159,590	3,425,792	$461,788,435	15,105

Details of Support by Participating Institutions

Doctoral Institutions — Private 14

Doctoral Institutions — Public 16

Comprehensive Institutions — Private 18

Comprehensive Institutions — Public 34

General Baccalaureate Institutions — Private 38

General Baccalaureate Institutions — Public 44

Professional and Specialized Institutions — Private 46

Professional and Specialized Institutions — Public 50

Two-Year Institutions — Private 50

Two-Year Institutions — Public 52

Independent Secondary and Elementary Schools 56

Symbols

NA	Not Available
*	Book Value

Technical Notes:

A. In the listing on the following pages, Column 27 does not show the total operating expenditures of the reporting institutions; it excludes the operating costs of dormitories, dining halls, student stores, and other "auxiliary enterprises" as well as all outlays of a capital nature.

B. In some instances the number of institutions listed is greater than the number tabulated, for two reasons: (1) some multicampus institutions are shown in summary as well as in detail, and (2) some of the component professional schools of major institutions are also listed separately.

DOCTORAL INSTITUTIONS—PRIVATE (56)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ADELPHI UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BOSTON COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BOSTON UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BRANDEIS UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BROWN UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BRYN MAWR COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CALIFORNIA INST. OF TECH.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CARNEGIE-MELLON UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CASE WESTERN RESERVE UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CATHOLIC UNIV. OF AMERICA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CHICAGO, UNIV. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CLAREMONT U. CTR. & GRAD. SCH.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CLARK UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
COLUMBIA UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CORNELL UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DARTMOUTH COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DENVER, UNIV. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DETROIT, UNIV. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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DUKE UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
EMORY UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FORDHAM UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GEORGE WASHINGTON UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GEORGETOWN UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HARVARD UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HOWARD UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ILLINOIS INST. OF TECH.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
JOHNS HOPKINS UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LEHIGH UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LOYOLA UNIV. OF CHICAGO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MARQUETTE UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MASSACHUSETTS INST. OF TECH.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MIAMI, UNIV. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NEW SCH. FOR SOC. RESEARCH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NEW YORK UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NORTHEASTERN UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NORTHWESTERN UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NOTRE DAME, UNIV. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PACIFIC, UNIV. OF THE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PENNSYLVANIA, UNIV. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PRINCETON UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
RENSSELAER POLY. INST.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
RICE UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ROCHESTER, UNIV. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ROCKEFELLER UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ST. JOHN'S UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ST. LOUIS UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SOUTHERN CALIFORNIA, UNIV. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SOUTHERN METHODIST UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
STANFORD UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SYRACUSE UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TUFTS UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TULANE UNIV. OF LOUISIANA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VANDERBILT UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WASHINGTON UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
YALE UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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DOCTORAL INSTITUTIONS—PUBLIC (94)

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DOCTORAL INSTITUTIONS—PUBLIC (CONT.)

COMPREHENSIVE INSTITUTIONS—PRIVATE (135)

COMPREHENSIVE INSTITUTIONS—PRIVATE (CONT.)

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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	32,759,663	14,126,773	4,844	IL BRADLEY UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23,654,596	8,109,295	6,613	CT BRIDGEPORT, UNIV. OF
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	32,380,000	12,194,000	3,338	PA BUCKNELL UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17,282,731	61,701,211	4,038	IN BUTLER UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,289,389	1,289,640	2,430	CA CALIFORNIA LUTHERAN COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,734,104	13,080,000	1,642	NC CAMPBELL UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21,487,704	3,641,310	4,269	CA CHAPMAN COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	36,482,268	14,277,331	2,631	NY COLGATE UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	46,418,470	14,380,846	5,913	NE CREIGHTON UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,875	TX DALLAS, UNIV. OF
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	67,350,663	10,241,470	10,533	OH DAYTON, UNIV. OF
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30,313,000	17,538,000	12,447	IL DEPAUL UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19,445,237	14,409,630	2,413	IN DEPAUW UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	33,648,755	14,683,180	6,008	IA DRAKE UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	67,044,997	38,489,644	12,416	PA DREXEL UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	41,886,860	7,556,244	6,362	PA DUQUESNE UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8,971,883	11,102,398	2,098	NY ELMIRA COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,066,776	707,182	1,643	MA EMERSON COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21,116,783	6,934,242	3,461	IN EVANSVILLE, UNIV. OF
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21,980,000	6,944,080	3,242	CT FAIRFIELD UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	88,473,208	1,962,913	16,796	NJ FAIRLEIGH DICKINSON UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20,791,741	637,691	7,864	FL FLORIDA INST. OF TECH.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16,291,727	22,916,511	3,013	SC FURMAN UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17,783,884	6,066,689	4,133	PA GANNON UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6,048,493	349,648	1,341	IL GEORGE WILLIAMS COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,408,888		307	VT GODDARD COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20,327,031	3,389,143	11,338	CA GOLDEN GATE UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28,487,451	12,336,318	4,620	WA GONZAGA UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21,481,499	46,128,544	4,290	VA HAMPTON INST.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12,768,997	20,233,175	1,627	TX HARDIN-SIMMONS UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48,098,808	21,080,088	8,842	CT HARTFORD, UNIV. OF
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	56,523,487	18,175,104	10,932	NY HOFSTRA UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8,487,027	30,330,139	979	VA HOLLINS COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6,320,986	3,480,101	665	CA HOLY NAMES COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4,923,231	14,387,640	1,083	SD HURON COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7,986,860	2,682,389	1,330	TX INCARNATE WORD COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9,482,891	13,356,648	3,242	IN INDIANA CENTRAL UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	32,096,038	11,668,778	5,232	NY ITHACA COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,466,040	4,428,238	2,419	FL JACKSONVILLE UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16,959,904	13,643,925	3,481	OH JOHN CARROLL UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4,487,234	58,333	1,833	CA JOHN F. KENNEDY UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16,776,762	1,908,079	12,888	CA LA VERNE, UNIV. OF
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	25,272,729	13,932,619	3,012	OR LEWIS AND CLARK COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10,130,481	28,348	2,811	IL LEWIS UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	97,133,481	7,407,040	10,790	NY LONG ISLAND UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,384,913	11,768,037	6,142	MD LOYOLA COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12,330,957	15,433,680	6,644	CA LOYOLA MARYMOUNT UNIV.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29,902,132	296,064,688	4,831	LA LOYOLA UNIV. IN NEW ORLEANS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,176,440	16,312,986	2,138	VA LYNCHBURG COL.
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COMPREHENSIVE INSTITUTIONS—PRIVATE (CONT.)

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COMPREHENSIVE INSTITUTIONS—PRIVATE (CONT.)

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COMPREHENSIVE INSTITUTIONS—PUBLIC (124)

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COMPREHENSIVE INSTITUTIONS—PUBLIC (CONT.)

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COMPREHENSIVE INSTITUTIONS—PUBLIC (CONT.)

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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	TN MARYVILLE COL.
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	IL MCKENDREE COL.
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MI MERCY COL. OF DETROIT
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	KS MID-AMERICA NAZARENE COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	NE MIDLAND LUTHERAN COL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	IL MILLIKIN UNIV.

GENERAL BACCALAUREATE INSTITUTIONS—PRIVATE (CONT.)

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MILLSAPS COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MISSOURI BAPT. COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MOBILE COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MONMOUTH COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MORAVIAN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MORNINGSIDE COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MORRIS BROWN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MOUNT HOLYOKE COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MOUNT MARTY COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MOUNT MARY COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MOUNT ST. CLARE COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MT. ST. JOSEPH-ON-THE-OHIO, C.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MOUNT ST. MARY COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MOUNT ST. MARY'S COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MOUNT ST. VINCENT, COL. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MOUNT UNION COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MOUNT VERNON COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MOUNT VERNON NAZARENE COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MUHLENBERG COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MUSKINGUM COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NAZARETH COL. OF ROCHESTER	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NEBRASKA WESLEYAN UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NEWBERRY COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NEW ENGLAND, UNIV. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NORTH CENTRAL COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NORTH PARK COL. & THEOL. SEM.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NORTHLAND COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NORTHWESTERN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NORWICH UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NOTRE DAME COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NOTRE DAME OF MARYLAND, COL. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NYACK COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OAKWOOD COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OBERLIN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OCCIDENTAL COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OGLETHORPE UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OHIO DOMINICAN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OHIO NORTHERN UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OHIO VALLEY COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OHIO WESLEYAN UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OKLAHOMA CHRISTIAN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OLIVET COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OTTAWA UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OTTERBEIN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OUR LADY OF HOLY CROSS COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OUR LADY OF THE ELMS, COL. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OZARKS, COL. OF THE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OZARKS, SCHOOL OF THE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PACIFIC UNION COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PACIFIC UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PINE MANOR COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PITZER COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
POINT PARK COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
POMONA COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

GENERAL BACCALAUREATE INSTITUTIONS—PRIVATE (CONT.)

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GENERAL BACCALAUREATE INSTITUTIONS—PRIVATE (CONT.)

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SOUTH, UNIV. OF THE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SOUTHERN SEVENTH-DAY ADV. COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SOUTHWESTERN ADVENTIST COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SOUTHWESTERN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SOUTHWESTERN UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SPRING HILL COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
STEPHENS COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
STERLING COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
STEUBENVILLE, UNIV. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
STONEHILL COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SUSQUEHANNA UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SWARTHMORE COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SWEET BRIAR COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TALLADEGA COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TAMPA, UNIV. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TAYLOR UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TEXAS LUTHERAN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
THOMAS MORE COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TRANSYLVANIA UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TREVECCA NAZARENE COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TRI-STATE UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TRINITY CHRISTIAN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TRINITY COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TRINITY COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TUSCULUM COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UNION COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UNION UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
URBANA UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
URSINUS COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VASSAR COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VIRGINIA WESLEYAN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VITERBO COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WABASH COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WALLA WALLA COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WALSH COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WARREN WILSON COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WARTBURG COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WASHINGTON AND JEFFERSON COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WASHINGTON AND LEE UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WASHINGTON COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WAYNESBURG COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WELLESLEY COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WELLS COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WESLEY COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WESLEYAN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WEST VIRGINIA WESLEYAN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WESTBROOK COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WESTMINSTER COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WESTMINSTER COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WESTMONT COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WHEATON COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WHEELING COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WHITMAN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WILBERFORCE UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WILLAMETTE UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3,037,344	3	9,938	9,934	2,090	937,314	2,473,633	NA	NA	NA	126	112,034	14,358,943	48,370,000	1,111	TN SOUTH, UNIV. OF THE
63,383	0	NA	0	3	0	0	0	0	0	12	10,300	NA	1,260,000	1,051	TN SOUTHERN SEVENTH-DAY ADV. COL.
6,679	0	3,133	3,133	563	52,609	99,092	0	0	1,944	3	1,000	3,031,930	4,415,091	700	TX SOUTHWESTERN ADVENTIST COL.
114,038	0	6,343	6,100	2,319	319,925	618,390	0	3	10,232	48	22,730	2,334,019	12,034,319	363	KS SOUTHWESTERN COL.
343,479	0	9,744	9,744	2,338	342,109	2,019,234	0	0	0	140	10,033	10,011,702	55,700,000	1,061	TX SOUTHWESTERN UNIV.
71,000	134,000	7,000	7,000	1,369	102,738	318,363	0	0	0	64	28,300	8,282,367	3,370,568	1,135	AL SPRING HILL COL.
884,838	0	43,217	33,084	4,153	438,287	710,970	5,978	3,300	37,428	144	64,695	9,629,368	9,705,690	1,132	MO STEPHENS COL.
334,773	3	6,607	4,903	1,473	135,300	612,300	0	0	0	38	45,000	2,376,372	1,473,836	367	KS STERLING COL.
3	0	4,338	NA	NA	43,372	1,902,304	1,438	13,918	43,767	98	23,067	4,841,370	108,290	1,107	OH STEUBENVILLE, UNIV. OF
101,003	0	7,979	7,362	2,099	231,903	231,380	0	3	0	64	37,041	10,714,452	9,503,124	2,745	MA STONEHILL COL.
4,304	3	9,624	6,730	2,133	133,900	318,209	0	0	14,000	201	61,793	18,200,000	4,000,000	1,033	PA SUSQUEHANNA UNIV.
493,343	297,103	14,442	13,376	7,943	1,098,836	1,392,339	0	0	0	808	282,487	19,017,000	143,944,000	1,370	PA SWARTHMORE COL.
891,487	13,700	13,340	9,440	4,036	778,417	1,093,536	0	0	112,844	293	97,398	9,129,337	27,144,583	886	VA SWEET BRIAR COL.
0	0	3,030	1,927	887	133,149	343,492	0	0	0	29	10,743	4,477,310	3,483,444	503	AL TALLADEGA COL.
47,343	4,300	13,038	7,383	837	34,040	[illegible]	17,334	43,481	61,395	41	9,933	14,379,108	3,334,041	2,303	FL TAMPA, UNIV. OF
383	3	13,744	14,443	1,453	213,400	[illegible]	3,090	0	NA	42	40,943	10,334,203	3,199,110	1,473	IN TAYLOR UNIV.
481,422	3	11,337	9,147	1,237	124,539	324,984	4,070	2,333	10,468	141	80,192	7,142,793	6,199,695	978	TX TEXAS LUTHERAN COL.
34,753	NA	4,110	3,240	1,423	40,078	99,061	0	400	444	96	7,812	4,870,724	2,879,144	1,319	KY THOMAS MORE COL.
2,010,953	0	7,338	4,904	1,498	123,239	379,963	0	0	85,977	48	13,204	4,703,440	47,411,393	817	KY TRANSYLVANIA UNIV.
3	4	10,177	1,309	413	31,092	23,277	4,270	1,103	28,417	328	382,893	3,091,471	1,419,173	987	TN TREVECCA NAZARENE COL.
33,000	44	13,000	13,300	3,304	104,433	471,438	0	29,743	34,473	367	44,732	4,334,223	4,945,037	1,467	IN TRI-STATE UNIV.
8,034	0	1,034	1,030	453	38,423	39,211	3,423	0	113	92	37,349	2,982,730	48,911	400	IL TRINITY CHRISTIAN COL.
91,414	44	7,949	4,080	2,934	491,091	1,083,441	0	3,734	9,473	137	84,387	8,447,314	2,701,173	846	DC TRINITY COL.
3	0	2,933	2,919	953	93,104	930,104	0	0	0	213	23,933	3,283,443	0	967	VT TRINITY COL.
3	3	4,948	4,000	1,330	171,133	410,080	10,409	1,000	10,179	4	7,900	2,372,383	[illegible]	411	TN TUSCULUM COL.
3	3	7,040	6,333	4,304	134,448	883,704	43,738	0	0	21	9,040	6,978,167	143,068	900	KY UNION COL.
33,381	1,382	9,044	4,373	1,040	73,304	88,017	974	0	138,338	13	4,140	6,374,387	2,889,113	1,038	TN UNION UNIV.
3	NA	3,708	3,700	330	4,753	28,770	0	7,774	4,313	3	1,473	NA	0	373	OH URBANA UNIV.
479,944	1,383	6,040	6,040	3,341	107,484	738,484	0	0	12,900	78	4,000	8,484,781	31,407,393	1,142	PA URSINUS COL.
3,138,900	33,384	23,473	24,440	13,093	3,233,917	2,483,409	0	0	378,488	894	178,874	27,794,973	123,044,000	2,330	NY VASSAR COL.
108,993	1,381	NA	NA	NA	NA	NA	138	0	NA	84	7,043	4,030,313	3,003,000	904	VA VIRGINIA WESLEYAN COL.
3,100	3	3,911	3,304	377	33,494	738,019	0	3,033	848,439	44	9,789	4,190,000	1,037,340	1,093	WI VITERBO COL.
290,091	443,793	4,720	4,709	3,304	891,394	790,049	0	0	0	80	138,400	4,021,301	79,030,000	774	IN WABASH COL.
404	3	13,000	13,200	4,330	391,080	300,031	16,783	303	19,048	38	88,134	11,903,183	498,943	1,037	WA WALLA WALLA COL.
NA	NA	NA	NA	NA	NA	NA	0	34,001	1,000	NA	NA	4,370,034	1,738,733	1,323	OH WALSH COL.
74,360	7,830	3,360	3,343	443	39,304	31,394	0	0	0	40	80,000	4,101,071	4,038,103	477	NC WARREN WILSON COL.
883,180	43,130	11,170	11,170	3,150	840,874	1,131,731	0	1,404	101,981	804	37,871	8,390,047	1,900,139	1,100	IA WARTBURG COL.
179,303	3	8,138	8,384	2,953	170,033	400,404	0	3	300	378	30,991	9,473,900	14,430,000	1,303	PA WASHINGTON AND JEFFERSON COL.
808,487	1,179,184	17,071	13,904	3,774	1,160,703	1,394,311	0	3,303	30,348	331	149,118	10,770,093	88,413,914	1,719	VA WASHINGTON AND LEE UNIV.
173,000	0	7,200	8,400	2,000	170,433	783,214	0	1,303	108,398	101	89,118	4,173,100	10,414,037	707	MD WASHINGTON COL.
319,447	4,048	7,000	7,003	1,393	163,439	341,102	0	3,303	14,100	134	33,704	4,471,373	3,640,900	793	PA WAYNESBURG COL.
3,488,300	44	NA	3	3	0	3	44	NA	137,300	1,349	403,033	34,330,020	149,910,340	4,170	MA WELLESLEY COL.
438,239	44	4,037	3,301	2,340	484,303	314,316	0	49,403	21,141	NA	NA	4,430,314	11,370,000	475	NY WELLS COL.
33,101	3	7,300	7,090	1,344	30,314	349,142	0	3	0	39	4,338	4,428,043	1,774,032	1,304	DE WESLEY COL.
220,328	43,231	7,340	7,900	1,930	183,493	381,034	NA	NA	NA	NA	NA	3,718,934	14,144,728	431	GA WESLEYAN COL.
481,777	44	14,440	11,304	2,070	167,373	743,089	0	4,301	23,448	487	74,718	8,373,766	3,376,768	1,409	WV WEST VIRGINIA WESLEYAN COL.
324,003	44	7,111	7,111	2,304	91,000	153,200	14	44	11,390	NA	NA	4,707,033	1,344,700	1,300	ME WESTBROOK COL.
418,138	3,919	7,413	4,703	1,392	132,133	490,382	0	3	1,030	139	84,816	8,394,274	13,300,000	814	MO WESTMINSTER COL.
443,434	13,300	17,434	10,071	2,377	193,393	[illegible]	0	3	0	343	83,944	12,430,024	13,714,343	1,344	PA WESTMINSTER COL.
390,304	109,304	9,038	9,053	1,084	287,401	533,359	14	3	44	74	41,300	8,104,304	2,779,223	902	CA WESTMONT COL.
30,713	483,408	12,073	11,363	3,934	320,724	83,018	0	3	9,700	367	239,487	11,376,303	21,344,000	1,330	IL WHEATON COL.
3	0	4,110	3,707	1,373	183,070	1,108,004	0	3	0	84	34,084	3,701,014	1,323,874	1,044	WV WHEELING COL.
338,330	44	8,797	4,797	4,433	731,403	[illegible]	0	4,304,233	110,030	277	37,900	12,371,701	44,334,700	1,242	WA WHITMAN COL.
3	3	3,447	3,447	382	73,131	1,193,314	NA	NA	NA	NA	NA	9,044,776	2,144,224	881	OH WILBERFORCE UNIV.
201,348	31,794	14,497	13,773	2,327	[illegible]	313,303	0	423	14,333	41	14,033	13,434,000	43,912,000	1,040	OR WILLAMETTE UNIV.

GENERAL BACCALAUREATE INSTITUTIONS—PRIVATE (CONT.)

[illegible]

GENERAL BACCALAUREATE INSTITUTIONS—PUBLIC (39)

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
300,936	10,000	11,023	11,923	303	66,336	106,063	1,779	16,100	16,340	97	23,479	10,109,000	25,000,000	1,991	MO WILLIAM JEWELL COL.
0	NA	10,301	0	0	13,302	69,922	0	0	33,300	10	6,013	6,606,720	3,441,235	701	MO WILLIAM WOODS COL.
2,790,306	NA	13,935	13,935	12,647	1,978,906	2,039,087	25,000	0	1,069,733	1,015	321,917	29,991,426	163,923,792	1,999	MA WILLIAMS COL.
91,318	NA	7,000	7,000	1,001	98,032	610,230	66,016	38,451	11,408	29	10,096	7,703,732	3,113,670	1,413	OH WILMINGTON COL.
16,001	0	6,774	6,606	3,103	308,797	[illegible]	0	0	NA	304	93,047	3,130,926	6,722,905	316	PA WILSON COL.
0	0	16,700	16,700	0	89,300	2,261,317	0	0	0	0	0	6,660,831	6,692,282	1,303	NC WINGATE COL.
303,231	137,793	20,706	18,600	2,330	638,393	939,801	13,000	8,000	145,301	613	117,609	17,099,367	26,375,706	2,233	OH WITTENBERG UNIV.
159,343	696	9,077	8,906	2,366	306,393	833,177	1,962	0	26,336	95	63,057	5,330,000	7,300,000	1,052	SC WOFFORD COL.
780,892	NA	19,897	19,851	6,637	497,706	956,690	0	0	6,443	739	217,933	10,276,893	33,706,377	1,761	OH WOOSTER, COL. OF
0	0	7,030	7,003	1,047	303,695	1,463,292	0	0	0	0	0	15,029,640	3,078,376	1,933	LA XAVIER UNIV. OF LOUISIANA
82,906	0	8,806	0	2	3,135	11,039	0	0	0	25	12,136	6,667,782	7,623,730	4,333	PA YORK COL. OF PENNSYLVANIA
0	0	11,607	6,102	266	66,702	32,112	0	0	0	11	6,430	19,098,016	747,269	2,033	MS ALCORN ST. UNIV.
0	0	10,817	9,106	291	[illegible]	74,906	2,100	0	0	6	5,979	16,121,720	130,167	2,440	AR ARKANSAS, UNIV. OF-PINE BLUFF
0	0	NA	0	0	0	0	0	0	0	0	0	12,168,672	37,016	5,194	OK CAMERON UNIV.
0	0	6,931	4,700	340	33,369	63,807	0	0	0	0	0	11,008,400	0	2,303	MD COPPIN ST. COL.
0	0	6,013	5,369	1,336	92,273	98,273	0	3,000	1,790	0	3,870	11,629,239	101,000	1,557	NC ELIZABETH CITY ST. UNIV.
0	0	6,080	6,003	346	16,032	76,971	93,019	67,663	0	32	6,160	17,637,900	10,000	2,717	WA EVERGREEN ST. COL.
0	0	6,700	2,070	236	[illegible]	190,761	0	0	0	0	0	13,190,202	0	2,679	NC FAYETTEVILLE ST. UNIV.
23,300	0	38,173	35,166	2,992	196,682	1,065,316	332,066	0	69,077	161	30,067	60,701,500	302,200	10,700	MI FERRIS ST. COL.
0	0	6,100	3,300	631	10,013	83,138	0	0	0	13	1,223	9,130,239	1,013,000	3,131	SC FRANCIS MARION COL.
0	0	6,600	3,777	1,006	21,161	26,933	0	33,693	10,300	33	1,230	NA	NA	3,006	IN INDIANA ST. UNIV.-EVANSVILLE
0	95,630	5,163	5,163	266	6,659	6,639	0	0	0	6	2,500	11,331,300	33,663	3,303	GA KENNESAW COL.
0	0	6,062	5,203	190	13,060	142,631	0	1,000	0	0	6,373	NA	137,103	2,631	KY KENTUCKY ST. UNIV.
0	0	NA	0	0	0	0	0	0	0	0	0	3,342,930	341,908	920	TX LAREDO ST. UNIV.
0	0	13,000	13,000	735	[illegible]	61,700	0	0	0	0	0	NA	0	2,600	PA LOCK HAVEN ST.COL.-U. OF PA.
0	0	14,307	12,161	6,716	130,700	[illegible]	663	0	21,336	120	11,392	10,633,061	2,216,916	2,621	VA LONGWOOD COL.
6,000	0	16,730	13,831	3,316	166,734	208,363	0	0	0	167	16,190	10,763,917	6,366,879	3,036	VA MARY WASHINGTON COL.
0	0	NA	NA	NA	NA	NA	0	0	0	0	0	8,368,197	0	4,369	CO MESA COL.
0	0	3,300	1,027	0	1,402	61,997	0	0	0	0	0	NA	0	3,400	MN METROPOLITAN ST. UNIV.
0	0	NA	0	0	0	0	0	0	0	0	0	10,622,893	316,712	6,200	MO MISSOURI SOUTHERN ST. COL.
5,433	0	10,967	8,316	2,393	33,133	77,601	0	16,165	731	30	2,239	13,397,276	191,106	3,577	NH NH. UNIV. OF-PLYMOUTH ST. COL.
0	0	7,031	7,031	1,073	32,966	36,000	0	0	0	38	1,170	9,376,770	0	2,100	MA NORTH ADAMS ST. COL.
0	0	3,738	1,000	267	8,063	11,130	0	0	0	0	0	9,647,760	712,631	2,636	NC NC AT ASHEVILLE, UNIV. OF
10,997	0	10,790	10,790	2,313	66,838	232,701	0	0	38,001	50	6,815	NA	635,656	2,710	SD NORTHERN ST. COL.
0	0	NA	0	0	0	0	13,000	[illegible]	33,000	30	10,000	NA	206,000	3,901	NJ RAMAPO COL. OF NEW JERSEY
0	0	3,003	2,703	170	14,131	30,293	137,900	38,930	167,691	0	2,690	6,836,636	132,097	1,330	MD ST. MARY'S COL. OF MARYLAND
0	0	6,300	6,300	673	60,077	106,040	0	0	0	0	0	12,876,793	13,000	2,012	GA SAVANNAH ST. COL.
0	0	9,935	390	943	71,673	103,333	10,670	0	0	19	5,396	23,603,903	93,900	4,226	SC SOUTH CAROLINA ST. COL.
190,303	0	3,283	2,300	130	8,366	9,066	10,330	0	0	56	5,273	NA	33,903	2,720	SC SC AT SPARTANBURG, UNIV. OF
0	0	6,000	6,000	633	13,310	37,691	0	0	1,633	31	36,670	8,012,079	2,985,832	2,263	AR SOUTHERN ARKANSAS UNIV.
201,000	0	NA	0	0	0	0	93,266	760,801	57,293	3	1,030	15,328,362	2,048,000	5,103	CO SOUTHERN COLORADO, UNIV. OF
0	0	8,300	8,300	6,300	63,110	80,935	0	0	66,230	0	0	NA	0	2,600	UT SOUTHERN UTAH ST. COL.
0	0	4,511	6,113	1,806	30,070	211,636	2,137	0	102	82	6,071	11,193,369	828,309	2,139	MN SOUTHWEST ST. UNIV.
0	0	3,936	2,030	839	20,352	20,322	777	300	0	77	3,015	2,266,628	0	6,231	NJ THOMAS A. EDISON ST. COL.
0	0	8,290	6,300	1,340	33,000	35,600	0	0	0	0	0	NA	380,037	1,066	ND VALLEY CITY ST. COL.
137,376	121,969	11,381	11,301	5,909	1,233,733	1,730,625	0	16,000	912,740	180	143,076	14,018,011	36,633,318	1,362	VA VIRGINIA MILITARY INST.
[illegible]	0	10,000	10,000	6,673	230,096	[illegible]	76,233	36,000	1,396,399	71	17,077	25,069,637	38,009,782	7,400	KS WASHBURN UNIV. OF TOPEKA
0	0	NA	0	3	0	0	136,839	230,966	97,665	22	8,106	NA	1,597,587	10,230	UT WEBER ST. COL.
0	0	5,600	6,030	826	10,669	[illegible]	0	0	0	0	0	21,320,723	70,083	6,000	WI WISCONSIN-U. OF-PARKSIDE
0	0	NA	0	0	0	0	0	0	0	0	0	60,796,275	769,699	NA	WI WISCONSIN-U. OF-UNIV. EXT.

PROFESSIONAL AND SPECIALIZED INSTITUTIONS—PRIVATE (105)

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
114,168	0	6,723	6,723	1,446	102,920	115,610	0	0	0	19	6,489	2,332,000	3,191,904	700	NY ALBANY LAW SCH.
0	0	3,127	2,999	673	74,324	393,678	0	0	0	39	14,261	33,097,607	8,742,469	592	NY ALBANY MEDICAL COL.
0	0	16,656	13,625	2,440	160,704	843,791	3,040	0	NA	453	62,690	8,237,711	3,363,432	904	AZ AMERICAN GRAD. SCH. INTL. MGT.
14,000	NA	3,337	3,026	695	47,900	365,391	0	0	0	79	23,002	2,615,618	11,168,624	583	MA ANDOVER NEWTON THEOL. SCH.
0	0	7,387	6,621	576	88,664	91,004	20,530	13,075	1,526	14	2,340	7,763,969	3,394,200	1,539	CA ART CENTER COL. OF DESIGN
103,387	NA	6,630	6,199	619	88,369	88,349	0	0	49,013	0	0	4,401,933	[illegible]	792	KY ASBURY THEOL. SEM.
330,909	0	3,680	3,000	324	18,620	341,009	0	0	0	806	74,203	1,497,067	4,521,130	163	OH ATHENAEUM OF OHIO
734,054	0	16,343	14,126	3,497	891,773	848,489	200,894	9,350	21,248	452	87,347	16,137,962	13,232,409	3,100	MA BABSON COL.
62,334	0	694	625	315	17,777	248,766	0	747	0	10	1,423	1,052,086	2,987,863	111	ME BANGOR THEOL. SEM.
711,440	0	6,676	6,030	744	800,184	323,884	0	0	0	24	90,870	164,700,000	111,400,000	8,016	TX BAYLOR COL. OF MEDICINE
30,000	40,290	NA	[illegible]	[illegible]	[illegible]	[illegible]	190,710	0	50,000	643	96,330	34,810,794	8,603,000	11,100	MA BENTLEY COL.
0	0	6,963	6,866	895	31,956	207,646	[illegible]	6,000	NA	98	22,360	7,903,361	1,306,911	1,730	NJ BLOOMFIELD COL.
0	0	1,130	1,130	130	1,430	1,430	0	0	0	16	10,398	NA	396,730	848	CT BRIDGEPORT ENGINEERING INST.
0	0	22,965	18,630	3,310	461,797	736,846	9,400	0	7,704	163	35,761	NA	14,931,164	6,363	RI BRYANT COL. BUSINESS ADMIN.
0	0	734	109	87	1,003	6,169	0	0	0	105	37,613	3,491,039	8,186,609	910	VA CBN UNIV.
0	0	2,000	2,000	80	3,162	100,473	3,000	0	8,039	16	11,631	10,736,647	19,400,000	897	CA CALIFORNIA INST. OF THE ARTS
0	0	1,075	1,537	163	9,331	38,903	0	0	0	3	130	7,408,865	87,394	1,016	CA CALIFORNIA SCH. PROF. PSYCH.
0	0	2,640	2,626	1,300	306,791	1,210,080	0	10,836	1,760	3	700	13,976,027	0	400	IL CHICAGO COL. OSTEO. MED.
37,002	NA	3,291	1,750	430	37,933	120,340	0	0	0	13	4,316	2,370,320	10,330,000	343	IN CHRISTIAN THEOL. SEM.
71,931	7,891	18,946	17,851	6,753	672,433	1,000,683	0	0	0	1,040	333,373	34,700,316	19,371,897	4,107	NY CLARKSON COL. OF TECH.
487,437	33,300	80,090	40,831	6,700	431,800	880,489	98,100	0	990	119	35,930	37,049,059	33,016,479	4,016	NY COLUMBIA UNIV. TEACHERS COL.
190,040	NA	11,763	8,622	328	10,836	611,864	308	0	37,083	300	33,730	3,004,494	300,393	887	NE CONCORDIA TEACHERS COL.
310,723	0	10,890	9,931	4,300	887,332	780,310	34,638	0	4,200	421	190,492	10,223,913	36,913,404	1,003	NY COOPER UNION
0	0	1,910	1,480	316	3,307	31,998	106,000	0	380	19	1,000	3,930,963	23,380	1,190	NH DANIEL WEBSTER COL.
9,000	0	4,000	4,000	1,100	308,378	800,972	35,000	0	0	39	14,630	3,133,090	4,044,944	815	PA DICKINSON SCH. OF LAW
0	0	4,000	1,000	117	8,030	137,301	0	0	0	0	0	4,397,902	32,970	1,300	OH DYKE COL.
10,300	0	8,000	7,408	2,300	147,200	307,019	1,000	3,000	6,200	0	0	4,300,763	8,334,133	1,270	NY D'YOUVILLE COL.
130,000	0	NA	0	0	0	0	0	0	0	0	0	NA	11,814,473	293	VA EASTERN VIRGINIA MEDICAL SCH.
82,379	69,630	1,000	1,000	667	83,079	809,306	0	0	0	24	14,990	NA	3,401,409	310	MO EDEN THEOL. SEM.
68,300	7,803	3,879	3,786	796	167,736	167,786	13,000	0	13,000	66	46,679	2,381,770	NA	600	IN FORT WAYNE BIBLE COL.
0	0	13,390	13,390	1,200	39,048	170,300	0	0	1,200	0	0	6,039,000	6,339,000	4,700	OH FRANKLIN UNIV.
12,077	NA	3,341	3,361	1,009	65,834	304,107	0	0	0	33	22,025	NA	11,632,700	333	IL GARRETT-EVANGELICAL THEOL.SEM.
0	0	19,000	14,300	1,303	101,956	486,884	0	803,703	0	33	6,133	38,290,404	962,362	2,406	MI GENERAL MOTORS INST.
78,363	0	3,709	2,300	648	38,409	1,488,190	14,000	968,291	0	0	0	6,091,730	4,162,333	909	MA GORDON-CONWELL THEOL. SEM.
0	0	4,400	4,190	1,830	33,844	163,884	8,397	0	13,343	165	33,700	4,444,200	100,000	2,107	PA GWYNEDD-MERCY COL.
337,371	0	NA	[illegible]	[illegible]	[illegible]	[illegible]	7,133	0	0	13	6,630	17,383,767	7,616,023	8,160	PA HAHNEMANN UNIV.
983,130	160,611	36,149	38,176	9,270	3,210,939	4,184,838	0	0	0	333	862,738	NA	[illegible]	1,833	MA HARVARD LAW SCHOOL
193,703	106,447	1,760	1,600	937	133,808	193,798	111,963	1,100	9,336	98	106,808	9,363,711	36,029,730	336	CA HARVEY MUDD COL.
0	0	3,000	1,700	47	950	11,340	0	881,360	133,373	0	0	6,108,210	0	633	NH HAWTHORNE COL.
0	0	7,912	3,037	313	64,790	101,760	0	17,761	36,330	13	3,930	8,187,383	166,267	1,490	ME HUSSON COL.
0	4,084	1,563	1,300	100	13,336	64,809	0	0	0	11	5,100	2,398,993	14,000,341	383	CO ILIFF SCHOOL OF THEOL.
0	0	NA	0	0	0	0	0	0	0	0	0	1,880,704	18,000	190	CA JESUIT SCH. OF THEOL.
0	0	1,012	1,300	33	4,040	46,374	90,307	6,490	3,000	1	200	1,990,100	993,403	894	MI KENDALL SCH. OF DESIGN
1,163,090	338,300	4,442	4,400	3,160	832,333	1,613,380	0	0	0	11	3,330	10,136,081	4,335,044	530	MO KIRKSVILLE COL. OF OSTEO. MED.
3,762	102,713	2,816	1,000	404	15,474	800,348	4,300	443	10,140	34	10,430	1,496,133	1,840,448	350	PA LANCASTER BIBLE COL.
14,367	0	1,270	3,270	304	84,411	171,166	0	0	0	20	7,330	1,330,239	3,022,049	344	PA LANCASTER THEOL. SEM.
0	0	NA	0	0	0	0	0	0	0	404	87,010	5,836,030	330,134	1,033	TX LE TOURNEAU COL.
117,069	7,639	1,340	1,100	360	81,381	830,341	0	0	0	13	10,000	1,321,076	4,380,730	136	KY LEXINGTON THEOL. SEM.
142,308	0	1,830	1,402	392	31,400	79,383	0	364	10	373	23,039	1,034,309	18,363,939	300	PA LUTHERAN THEOL. SEM.-PHILA.
0	0	2,630	2,400	984	100,828	378,010	0	0	30,013	0	0	11,002,021	8,444,701	800	PA MEDICAL COL. OF PENNSYLVANIA
133,089	0	4,965	4,700	1,300	267,404	330,073	NA	0	NA	11	14,000	69,301,423	8,093,393	1,200	WI MEDICAL COL. OF WISCONSIN
437,293	0	4,030	4,341	793	497,776	7,300,834	1,136	0	3,816	171	73,033	27,017,113	14,710,913	631	TN MEHARRY MEDICAL COL.
0	0	330	400	87	3,923	84,836	NA	NA	0	10	8,293	1,433,943	433,007	242	TN MEMPHIS ACADEMY OF ARTS
0	0	NA	0	0	0	0	0	0	0	0	0	1,043,433	14,905	322	FL MIAMI CHRISTIAN COL.
30,000	0	14,300	14,300	2,340	167,439	1,890,844	143,343	290,133	67,301	323	32,391	11,013,989	928,898	2,333	WI MILWAUKEE SCH. OF ENGINEERING

PROFESSIONAL AND SPECIALIZED INSTITUTIONS—PRIVATE (CONT.)

[illegible]	1	2	3	4	5	6	7	8	9	10	11	12	13
MOORE COL. OF ART	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NATIONAL COL. OF EDUCATION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NEW ENGLAND SCHOOL OF LAW	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NEW HAMPSHIRE COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NEW YORK MEDICAL COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NORTHWESTERN COL. OF CHIRO.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OSTEO. MED. PACIFIC, COL. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PACE UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PACIFIC SCH. OF RELIGION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PALMER COL. OF CHIROPRACTIC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PHILADELPHIA COL. PHARM.& SCI.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PHILADELPHIA COL. TEX. & SCI.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
POLYTECHNIC INST. OF NEW YORK	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PONTIFICAL COL. JOSEPHINUM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PORTLAND SCH. OF ART	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
POST COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PRINCETON THEOL. SEM.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
REDLANDS, UNIV. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
RHODE ISLAND SCH. OF DESIGN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
RIDER COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ROCKHURST COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ROSE-HULMAN INST. OF TECH.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ST. JOSEPH THE PROVIDER, C. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ST. MARY, COL. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ST. MEINRAD SEM. OF THEOL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ST. TERESA, COL. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ST. VINCENT COL. & SEM.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SAN FRANCISCO THEOL. SEM.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SCARRITT COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SOUTHERN CA. COL. OF OPTOMETRY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SOUTHWESTERN ASSEM. GOD COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SOUTHWESTERN UNIV. SCH. OF LAW	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SPRING GARDEN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
STEVENS INST. OF TECH.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TEXAS CHIROPRACTIC COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
THEOLOGY AT CLAREMONT, SCH. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
THOMAS COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
THOMAS JEFFERSON UNIV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TRINITY LUTHERAN SEM.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UNION THEOL. SEM.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UNITED THEOL. SEM.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VILLA MARIA COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WALSH COL. ACCT. & BUS. ADMIN.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WEBB INST. OF NAVAL ARCH.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WENTWORTH INST. OF TECH.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WESLEY THEOL. SEM.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WESTMINSTER CHOIR COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WESTMINSTER THEOL. SEM.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WHEELOCK COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WORCESTER POLYTECHNIC INST.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2,306	0	2,000	2,000	313	19,036	31,311	0	0	6,448	20	5,030	3,974,033	4,894,759	326	PA MOORE COL. OF ART
64,797	0	11,000	11,000	2,446	113,872	868,034	10,071	14,216	47,227	69	20,611	17,375,112	261,187	4,395	IL NATIONAL COL. OF EDUCATION
0	4,164	4,278	3,882	861	32,439	64,496	0	0	0	29	3,166	6,486,310	3,134,761	968	MA NEW ENGLAND SCHOOL OF LAW
30,000	0	13,000	9,580	1,037	33,466	97,303	0	2,300	0	63	10,392	22,000,000	692,646	7,335	NH NEW HAMPSHIRE COL.
0	0	6,480	3,000	1,196	288,323	358,943	NA	17,000	NA	NA	NA	89,083,000	3,073,600	1,219	NY NEW YORK MEDICAL COL.
2,000	0	1,321	1,306	407	26,002	28,712	8,630	0	10,661	3	3,000	3,906,600	133,700	690	MN NORTHWESTERN COL. OF CHIRO.
0	0	65	65	2	73	88,392	0	17,615	0	2	450	6,633,730	396,716	331	CA OSTEO. MED. PACIFIC, COL. OF
0	0	30,930	30,930	7,062	268,936	619,374	0	0	0	963	135,303	84,148,395	17,366,396	23,861	NY PACE UNIV.
293,323	61,621	1,900	1,900	237	36,963	390,924	0	0	0	15	36,462	2,193,989	11,178,306	225	CA PACIFIC SCH. OF RELIGION
35,000	0	12,732	12,732	416	76,003	77,996	0	0	6,662	0	0	11,689,674	2,279,716	1,866	IA PALMER COL. OF CHIROPRACTIC
362,701	0	7,357	7,100	2,003	96,270	106,103	0	0	0	216	21,366	8,163,712	30,442,330	1,703	PA PHILADELPHIA COL. PHARM.& SCI.
35,030	0	9,037	7,061	1,369	88,330	233,963	113,130	6,617	105,367	30	12,767	9,097,533	6,325,682	2,766	PA PHILADELPHIA COL. TEX. & SCI.
37,015	66	36,900	25,322	6,113	435,307	869,039	3,070,730	0	0	960	163,135	30,109,012	10,429,060	5,030	NY POLYTECHNIC INST. OF NEW YORK
86,275	0	1,700	1,666	809	87,616	151,612	0	0	31,020	41	6,917	2,010,325	7,462,512	322	OH PONTIFICAL COL. JOSEPHINUM
2,793	0	658	656	66	1,032	20,367	0	0	0	0	0	1,001,733	296,420	233	ME PORTLAND SCH. OF ART
0	0	3,340	6,230	376	6,379	173,016	1,000	303	5,731	30	2,130	6,109,037	1,520,020	1,430	CT POST COL.
3	0	9,371	8,293	1,380	101,061	906,231	0	0	0	0	0	10,502,671	109,366,777	873	NJ PRINCETON THEOL. SEM.
117,330	1,006,163	20,222	23,211	6,368	473,139	1,317,036	660	11,630	60,100	221	66,337	16,700,091	10,602,291	2,363	CA REDLANDS, UNIV. OF
63,000	3,222	NA	0	0	0	0	0	0	0	33	13,491	10,006,003	20,622,000	1,773	RI RHODE ISLAND SCH. OF DESIGN
9,313	66,667	20,990	26,175	6,362	234,036	137,631	0	86,600	131,767	1,006	101,366	20,663,000	3,016,000	5,063	NJ RIDER COL.
NA	NA	NA	NA	NA	NA	NA	0	3,199	0	NA	NA	9,691,066	8,999,370	3,190	MO ROCKHURST COL.
931,636	300,000	6,122	5,735	2,017	353,201	1,307,666	NA	NA	NA	609	116,119	8,037,000	35,000,000	1,347	IN ROSE-HULMAN INST. OF TECH.
0	0	830	730	211	3,333	65,782	6,319	3,063	303	9	3,333	1,261,306	0	366	VT ST. JOSEPH THE PROVIDER, C. OF
0	0	66	NA	NA	NA	NA	0	0	0	0	0	6,279,170	2,311,190	1,207	ME ST. MARY, COL. OF
663,600	363,000	3,309	6,066	1,068	112,166	120,231	266	0	387,711	69	90,670	2,638,370	3,100,000	313	IN ST. MEINRAD SCH. OF THEOL.
14,621	34,903	8,000	7,778	2,738	151,000	679,085	3,100	0	0	107	17,593	6,720,319	2,648,796	366	NH ST. THERESA, COL. OF
0	0	9,630	9,168	2,871	169,309	332,900	0	0	0	116	33,907	7,396,672	2,771,701	1,163	PA ST. VINCENT COL. & SEM.
213,206	0	6,000	6,000	790	6,819	1,970,267	0	0	0	36	30,609	66	16,000,000	1,039	CA SAN FRANCISCO THEOL. SEM.
101,001	66,000	3,660	3,600	898	33,200	760,056	0	0	66,336	26	23,161	1,176,606	3,031,010	90	TN SCARRITT COL.
3	63,703	12,953	12,276	7,669	663,211	650,093	37,730	0	13,666	620	106,157	13,932,303	3,211,003	3,110	NY SIENA COL.
14,333	0	2,371	2,609	306	31,296	69,306	0	0	0	0	840	6,320,360	616,036	378	CA SOUTHERN CA. COL. OF OPTOMETRY
0	0	NA	0	0	0	0	0	0	0	0	0	2,706,883	626,533	379	TX SOUTHWESTERN ASSEM. GOD COL.
0	0	7,132	6,316	329	20,630	27,302	0	0	0	0	2,243	7,000,630	360,760	1,030	CA SOUTHWESTERN UNIV. SCH. OF LAW
3	0	2,762	2,704	253	9,766	12,023	12,370	0	0	63	10,358	3,018,130	300,670	1,793	PA SPRING GARDEN COL.
113,800	3,636	13,617	13,617	3,626	611,030	703,361	NA	NA	NA	1,365	210,671	30,091,151	63,216,536	3,333	NJ STEVENS INST. OF TECH.
0	NA	0	0	0	0	0	72,013	0	0	3	800	3,667,023	190,000	669	TX TEXAS CHIROPRACTIC COL.
330,003	64,306	1,336	1,336	133	1,013	993,671	0	10,000	2,313	103	66,966	2,631,312	2,267,070	369	CA THEOLOGY AT CLAREMONT, SCH. OF
3	0	6,000	2,000	103	9,926	77,018	1,003	3	1,200	6	783	2,016,093	0	838	MO [illegible] COL.
1,011,063	336,600	13,086	12,009	6,006	930,363	1,001,013	0	0	6,363	63	10,130	79,368,300	65,982,300	1,931	PA THOMAS JEFFERSON UNIV.
872,623	0	2,079	2,679	330	30,611	93,003	0	0	6,100	131	37,021	3,666,931	7,666,000	386	OH TRINITY LUTHERAN SEM.
91,600	0	7,300	6,300	1,766	199,010	703,306	0	0	0	97	16,640	6,930,036	30,636,616	661	NY UNION THEOL. SEM.
0	0	2,363	2,367	1,190	113,010	303,063	0	0	0	86	9,000	1,796,316	3,338,697	386	OH UNITED THEOL. SEM.
NA	0	3,912	3,631	732	67,193	179,692	1,167	0	30	36	10,069	3,009,233	17,660	619	PA VILLA MARIA COL.
0	0	2,960	2,137	368	30,036	366,396	0	32,170	800	63	6,300	3,060,030	310,660	2,073	MI WALSH COL. ACCT. & BUS. ADMIN.
317,307	0	660	660	329	146,323	363,951	0	903	3,300	103	66,712	1,103,313	13,136,035	63	NY WEBB INST. OF NAVAL ARCH.
3,003	0	10,306	17,132	1,628	80,976	607,986	680,323	17,631	2,003	132	13,663	21,908,237	19,037,310	6,000	MA WENTWORTH INST. OF TECH.
138,700	0	2,130	1,000	690	36,063	308,331	0	0	0	33	9,300	2,701,311	2,636,039	612	DC WESLEY THEOL. SEM.
17,071	0	6,102	3,033	1,366	76,712	336,610	0	1,300	9,711	66	19,778	6,028,190	1,366,761	396	NJ WESTMINSTER CHOIR COL.
NA	NA	NA	0	0	0	0	0	0	0	NA	NA	1,988,833	661,696	670	PA WESTMINSTER THEOL. SEM.
39,031	0	7,030	7,700	2,230	221,313	339,969	0	0	0	30	9,037	[illegible]	1,367,639	630	MA WHEELOCK COL.
780,273	33,170	16,163	16,163	3,706	966,707	1,366,330	102,333	6,063	0	2,369	338,037	36,671,391	83,176,337	3,093	MA WORCESTER POLYTECHNIC INST.

PROFESSIONAL AND SPECIALIZED INSTITUTIONS—PUBLIC (18)

TWO-YEAR INSTITUTIONS—PRIVATE (42)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9,617,810	0	16,719	17,037	2,306	256,299	356,388	80	88	153,461	74	47,110	203,002,333	0	3,044	CA CA., UNIV. OF-SAN FRANCISCO
31,889	86,996	16,078	16,979	2,136	253,344	470,333	0	0	0	350	236,177	31,761,480	6,289,037	3,900	CO COLORADO SCHOOL OF MINES
188,199	0	34,096	20,437	13,029	1,738,000	2,504,000	0	0	0	3,752	478,343	97,440,881	40,065,387	10,910	GA GEORGIA INST. OF TECH.
0	0	88	0	0	0	0	6,081,791	7,433	886,462	32	8,243	6,386,261	1,313,329	850	ME MAINE MARITIME ACADEMY
0	0	9,391	8,123	1,800	35,767	36,327	0	0	16,883	11	1,366	6,110,237	400,038	2,113	ME MAINE, UNIV. OF-FARMINGTON
59,723	0	46,310	31,400	7,066	778,228	3,597,900	0	182,500	19,299	1,260	228,076	88,010,010	2,601,236	4,933	MI MICHIGAN TECH. UNIV.
0	0	2,741	2,423	361	84,987	68,711	300	324,700	189,571	149	43,007	12,313,320	179,210	2,306	MT MONTANA COL. OF MIN.SCI.&TECH.
77,696	0	10,300	13,000	3,794	115,428	180,011	143,449	176,414	0	1,086	136,054	37,331,400	846,727	3,007	NJ NEW JERSEY INST. OF TECH.
498,382	0	9,900	9,900	1,392	145,336	165,036	0	0	163,038	0	0	56,447,027	11,838,672	1,103	OR OREGON HEALTH SCIENCES UNIV.
0	0	6,230	6,250	1,300	47,076	203,404	0	0	0	0	0	86	0	3,300	GA SOUTHERN TECH. INST.
0	0	0	0	0	0	0	0	0	0	0	0	20,403,293	13,596	396	TX TEXAS COL. OF OSTEO. MED.
98,083	0	485	0	0	0	0	441,944	0	0	0	12,588	147,274,925	16,204,750-	1,339	TX TEX.-U.OF-HLTH. CTR.-DALLAS
0	0	6,127	0	0	0	31,331	0	0	0	88	88	130,033,036	3,020,428-	2,979	TX TEX.-U.OF-HLTH. CTR.-HOUSTON
0	0	88	88	88	0	0	0	0	0	88	88	120,031,931	4,340,461-	2,318	TX TEX.-U.OF-HLTH. CTR.-S.ANTONIO
0	0	3,653	88	88	0	0	0	0	0	88	88	13,303,400	23,000-	0	TX TEX.-U.OF-HLTH. CTR.-TYLER
0	0	88	88	88	88	88	12,433	0	2,310	0	700	3,137,113	317,917-	88	TX TEX.-U.OF-INST. TEXAN CULTURES
0	0	4,323	0	0	0	0	0	0	17,711	0	1,000	131,884,092	17,334,183-	2,300	TX TEX.-U.OF-MED. BR.-GALVESTON
0	0	88	88	88	88	2,432,330	0	0	0	0	0	127,335,403	40,018,244-	0	TX TEX.-U.OF-SYSTEM CANCER CTR.
0	0	6,907	6,907	360	28,177	33,037	0	0	0	33	3,400	4,386,067	4,377,373	1,393	NY ACADEMY OF AERONAUTICS
34,483	0	7,088	6,888	1,388	22,342	113,117	160	0	3,000	106	9,618	2,964,033	3,846,176	338	MA BAY PATH JC.
0	0	6,088	7,880	388	53,433	113,306	7,900	0	110,747	0	0	4,176,431	1,337,300	711	NY CAZENOVIA COL.
73,698	0	6,138	8,088	388	241,433	406,301	0	0	0	31	11,083	3,282,403	782,472	293	KS CENTRAL COL.
0	0	8,079	6,381	376	28,037	176,488	38,300	4,300	225	76	6,353	4,831,800	851,800	1,082	NY CHAMPLAIN COL.
0	0	7,838	7,867	491	38,098	73,738	0	0	0	0	0	4,888,737	2,440,043	899	NC CHOWAN COL.
6,300	0	11,303	10,611	2,635	37,309	123,900	3,087	3,301	100	101	9,463	6,921,147	3,110,000	2,300	MA DEAN JC.
84,331	0	10,300	3,711	75	6,310	160,438	0	790	3,800	0	2,773	1,721,074	0	861	KS DONNELLY COL.
0	0	5,310	3,110	913	38,083	100,038	2,300	0	0	88	9,300	4,012,039	337,434	1,330	NY ELIZABETH SETON COL.
0	0	13,879	10,090	0	37,016	67,433	0	0	0	88	5,043	4,017,770	1,016,290	760	MA ENDICOTT COL.
0	0	753	480	45	430	7,345	1,417	9,777	10,307	0	2,900	441,443	14,183	323	IL FELICIAN COL.
19,406	0	6,014	6,091	986	18,741	44,533	0	0	0	19	0	0	0	840	PA HARCUM JC.
0	0	6,388	6,388	1,420	188,471	433,401	0	0	0	13	3,403	3,392,221	738,833	330	KS HESSTON COL.
0	0	3,918	0	0	0	0	0	0	0	0	0	2,873,127	117,380	488	NY HILBERT COL.
7,980	0	9,388	9,388	1,795	74,430	303,433	0	0	0	244	16,330	4,400,368	3,302,954	1,490	PA KEYSTONE JC.
3,791	0	3,938	3,108	1,700	4,010	38,273	16,000	350	1,230	0	438	2,789,163	3,936,742	1,830	PA LACKAWANNA JC.
38,303	0	10,780	10,984	388	113,046	160,313	0	0	0	73	9,146	2,865,434	1,980,413	397	MA LASELL JC.
25,903	0	3,711	3,712	238	30,304	317,377	0	0	0	73	16,033	1,365,360	6,799,340	370	KY LEES JC.
107,707	0	3,707	3,727	188	38,337	377,350	0	0	0	43	18,976	2,402,423	2,499,327	878	NC LEES-MCRAE COL.
0	0	13,844	13,008	1,300	79,333	103,047	0	26,243	38,881	43	3,043	3,072,400	0	738	NC LOUISBURG COL.
0	0	0	0	0	0	37,336	0	0	0	0	4,980	1,146,033	0	853	NY MARIA REGINA COL.
94,000	0	1,788	1,810	313	1,613	13,333	1,200	0	0	33	36,938	88	0	323	MA MARIAN COURT JC. COL. OF BUS.
0	0	8,384	3,040	101	3,330	12,839	0	0	4,388	33	38,431	0	0	558	AL MARION MILITARY INST.
0	0	2,911	3,303	48	784	14,643	440	0	0	0	6,934	537,889	0	316	MS MARY HOLMES COL.
103,704	0	3,843	3,330	294	12,963	146,908	0	17,768	336,193	0	0	3,077,840	9,833,698	393	KY MIDWAY COL.
0	0	3,327	3,367	388	40,407	183,137	0	0	0	45	33,137	2,468,976	2,848,435	340	NC MONTREAT-ANDERSON COL.
372,406	0	2,100	2,180	0	708	166,903	0	0	4,796,329	126	16,091	2,385,930	1,333,121	383	NC MOUNT OLIVE COL.
73,330	0	6,000	2,000	0	28,107	371,180	0	0	7,962	0	0	3,320,910	1,126,190	381	SC NORTH GREENVILLE COL.
0	140,183	11,100	6,700	123	17,386	323,773	0	0	0	0	0	2,851,433	125,743	382	PA NORTHEASTERN CHRISTIAN JC.
0	0	6,700	6,130	403	32,000	83,000	40,000	0	0	13	0	3,100,080	1,273,080	383	NY PAUL SMITH'S COL. ARTS & SCI.
13,338	88	3,370	3,370	1,190	86,132	123,300	0	7,300	3,110	11	21,581	3,399,131	3,067,080	388	NC PEACE COL.
3,000	0	17,707	14,251	1,481	81,330	116,183	0	0	1,010	75	6,916	6,091,017	3,421,790	1,468	PA PEIRCE JC.

TWO-YEAR INSTITUTIONS—PRIVATE (CONT.)

[illegible]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PRESENTATION COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ST. AUGUSTINE CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ST. CATHARINE COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ST. MARY'S COL. OF O'FALLON	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SPARTANBURG METHODIST COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SPRINGFIELD COL. IN ILLINOIS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WALDORF COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] JC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TWO-YEAR INSTITUTIONS—PUBLIC (94)

[illegible]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
ALAMO CC. DIST.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ALEXANDER CITY ST. JC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ALPENA CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ANNE ARUNDEL CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AUSTIN CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BEAVER CO., CC. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BISMARCK JC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BRISTOL CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BUCKS CO. CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CATONSVILLE CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CENTRAL PIEDMONT CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CENTRAL TECH. CC. AREA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CHESTERFIELD-MARLBORO T.C.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CLARK TECH. COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
COASTAL CAROLINA CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
COLORADO MOUNTAIN COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CUMBERLAND CO. COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DALLAS CO. CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DELAWARE CO. CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DELAWARE TECH. & CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DENVER, CC. OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DODGE CITY CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
EDISON CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] CO. JC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FAYETTEVILLE TECH. INST.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FOOTHILL-DE ANZA CC. DIST.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FORT SCOTT CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FRANK PHILLIPS COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GADSDEN ST. JC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GOLDEN WEST COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] JC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GREENFIELD CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] COL.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GULF COAST CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HENDERSON CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HENRY FORD CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HOWARD CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HOWARD CO. JC. DIST	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ISOTHERMAL CC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
JOLIET JC.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

0	0	3,160	4,044	689	25,566	188,280	0	0	0	13	2,623	1,603,033	831,399	356	SD PRESENTATION COL.
0	0	NA	0	0	0	0	0	0	0	0	0	2,086,596	0	1,001	IL ST. AUGUSTINE CC.
13,296	11,613	2,300	2,000	226	24,173	192,595	1,400	0	960	2	2,700	NA	0	227	KY ST. CATHARINE COL.
0	0	4,448	4,448	652	16,000	16,395	0	0	0	0	0	NA	0	680	MO ST. MARY'S COL. OF O'FALLON
27,013	0	5,114	4,482	993	37,482	493,712	0	2,744	842	45	5,993	3,330,220	1,200,000	1,033	SC SPARTANBURG METHODIST COL.
18,000	0	3,700	3,337	132	18,324	117,387	2,341	1,550	8,000	20	8,195	1,234,386	180,149	532	IL SPRINGFIELD COL. IN ILLINOIS
15,000	0	773	731	63	2,507	22,141	0	0	13,700	14	4,315	798,389	0	70	VT STERLING COL.
173,877	0	3,000	NA	NA	58,550	56,850	0	0	0	0	0	3,603,130	1,199,833	685	MI SUOMI COL.
62,030	44,300	9,618	8,543	1,139	123,070	315,097	0	0	7,990	472	28,038	3,376,343	817,884	623	IA WALDORF COL.
3,111	0	2,314	2,314	363	14,032	230,826	0	0	4,204	9	635	1,443,495	1,133,396	452	MS WOOD JC.
0	0	NA	0	0	0	0	39,368	81,176	24,863	0	0	54,026,538	315,578	28,083	TX ALAMO CC. DIST.
0	0	NA	0	0	0	0	0	0	0	0	0	NA	0	1,098	AL ALEXANDER CITY ST. JC.
0	0	NA	0	0	0	0	98	1,483	0	6	1,298	3,930,448	99,587	1,842	MI ALPENA CC.
0	0	NA	0	0	0	0	0	0	0	0	0	15,277,111	93,228	8,096	MD ANNE ARUNDEL CC.
0	0	NA	0	0	0	0	0	0	0	0	0	NA	0	987	MN AUSTIN CC.
0	0	6,200	0	0	0	0	0	0	0	0	0	6,378,360	0	2,348	PA BEAVER CO., CC. OF
0	0	NA	0	0	0	0	0	0	0	0	0	3,958,270	1,313,900	2,484	ND BISMARCK JC.
0	0	NA	0	0	0	0	0	0	0	0	0	NA	0	4,506	MA BRISTOL CC.
0	16,225	NA	0	0	0	0	0	0	0	0	0	NA	2,816	9,137	PA BUCKS CO. CC.
0	0	NA	0	0	0	0	0	31,000	0	2	65	23,970,781	58,253	10,789	MD CATONSVILLE CC.
0	0	NA	0	0	0	0	0	0	0	0	0	24,419,366	330,701	22,838	NC CENTRAL PIEDMONT CC.
0	0	NA	0	0	0	0	82,031	0	0	0	0	11,473,913	63,500	5,797	OR CENTRAL TECH. CC. AREA
0	0	NA	0	0	0	0	150	0	0	0	0	2,114,599	4,081	697	SC CHESTERFIELD-MARLBORO T.C.
0	0	4,390	0	0	0	0	0	0	0	0	0	NA	31,076	2,889	OH CLARK TECH. COL.
0	0	NA	0	0	0	0	0	0	0	0	0	NA	0	20,397	NC COASTAL CAROLINA CC.
0	0	0	0	0	0	0	0	0	0	0	0	10,904,184	49,634	7,850	CO COLORADO MOUNTAIN COL.
0	0	NA	0	0	0	0	0	0	0	0	0	6,301,004	28,990	2,336	NJ CUMBERLAND CO. COL.
0	0	8,030	6,303	295	2,491	8,736	0	10,003	0	3	389	23,213,000	0	7,188	NY CUNY-LA GUARDIA CC.
0	0	NA	0	0	0	0	393,781	64,986	31,110	3	1,135	93,118,198	373,198	30,823	TX DALLAS CO. CC.
0	0	16,438	3,427	36	763	113,630	370,000	0	0	0	4,135	18,386,387	91,079	7,254	PA DELAWARE CO. CC.
0	0	NA	0	0	0	0	0	680,299	37,000	4	1,100	NA	137,000	9,200	DE DELAWARE TECH. & CC.
0	9,278	NA	0	0	0	0	0	0	0	0	0	NA	9,270	20,184	CO DENVER, CC. OF
0	0	2,800	1,893	1,580	35,300	54,441	0	0	0	0	0	3,300,000	181,000	1,456	KS DODGE CITY CC.
52,350	875,303	NA	0	0	0	0	0	3,000	0	2	150	8,418,037	1,743,100	5,967	FL EDISON CC.
0	0	NA	NA	0	0	4,301	0	0	0	0	0	1,477,000	7,100	470	GA EMANUEL CO. JC.
0	0	NA	0	0	0	0	3,000	0	0	0	0	13,880,000	1,038	8,088	NC FAYETTEVILLE TECH. INST.
0	0	NA	0	0	0	0	270,716	73,830	0	88	9,380	[illegible]	94,100	30,613	CA FOOTHILL-DE ANZA CC. DIST.
0	0	4,900	58	17	6,703	3,961	0	0	0	2	383	[illegible]	168,187	1,800	KS FORT SCOTT CC.
0	0	NA	0	0	0	0	0	0	0	0	0	4,789,778	0	[illegible]	TX FRANK PHILLIPS COL.
0	0	NA	0	0	0	0	0	0	0	0	0	NA	40,000	[illegible]	AL GADSDEN ST. JC.
0	0	0	0	0	0	0	33,387	8,000	31,816	0	8,030	81,790,000	30,831	15,986	CA GOLDEN WEST COL.
3,083	0	4,030	4,300	188	11,364	85,326	0	0	0	0	800	[illegible]	0	1,814	GA GORDON JC.
0	0	NA	0	0	0	0	0	0	0	0	48	6,081,866	8,887,661	[illegible]	MA GREENFIELD CC.
0	3,000	NA	0	0	0	0	0	36,074	28,173	0	0	NA	42,787,787	18,333	CA GROSSMONT COL.
0	0	NA	0	0	0	0	0	0	0	0	0	6,130,068	0	6,506	FL GULF COAST CC.
21,875	44,543	NA	0	0	0	0	0	0	0	0	0	2,063,783	NA	1,098	KY HENDERSON CC.
0	0	0	0	0	0	0	0	0	0	0	0	NA	0	16,130	MI HENRY FORD CC.
0	0	NA	0	0	0	0	450	1,500	0	2	400	6,726,460	27,007	2,307	MD HOWARD CC.
0	0	78,395	3,269	0	0	0	0	0	0	0	0	NA	14,000	1,918	TX HOWARD CO. JC. DIST
0	0	NA	0	0	0	0	0	0	0	0	0	NA	0	2,571	NC ISOTHERMAL CC.
0	0	7,000	7,300	129	3,212	11,371	38,544	308	4,840	0	3,083	15,057,371	50,684	16,236	IL JOLIET JC.

TWO-YEAR INSTITUTIONS—PUBLIC (CONT.)

[illegible]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
LAKESHORE TECH. INST.	106,208	34,497	0	71,711	0	0	0	303	0	87,093	0	17,920	0	0
LAKE CC.	110,327	23,000	87,327	0	0	0	0	0	0	73,700	0	36,627	0	0
LETHBRIDGE CC.	26,190	26,190	0	0	0	0	0	0	0	25,190	0	1,000	0	0
LORAIN CO. CC.	293,517	4,000	16,676	4,420	250,774	39,667	0	3,130	0	175,011	59,000	31,376	0	0
LOWER COLUMBIA COL.	100,000	0	100,000	0	0	3	0	0	0	75,000	0	25,000	0	0
MAYLAND TECH. COL.	22,477	12,360	6,283	0	0	3,834	0	822	0	6,763	0	6,776	0	6,136
MIAMI-DADE CC.	385,460	13,752	172,016	0	169,150	31,652	0	2,820	3	236,165	31,393	81,468	13,065	21,507
MID PLAINS TECH. CC. AREA	116,608	0	116,608	0	0	0	3	0	0	116,608	0	0	0	0
MIDLANDS TECH. COL.	162,698	1,039	31,363	106,616	0	0	3	0	3	19,672	7,710	135,316	0	0
MINN.,U. OF-TECH. COL.-WASECA	43,100	13,084	27,826	2,290	0	0	0	389	775	20,001	0	23,315	0	0
MIRA COSTA COL.	14,078	3,270	8,803	2,005	0	0	0	0	0	4,263	0	4,700	0	5,135
MITCHELL CC.	47,462	5,300	41,962	0	0	0	0	0	0	30,462	0	0	0	16,750
MONROE CO. CC.	65,109	3,923	32,096	7,088	0	23,000	0	5,700	0	33,623	0	7,336	0	13,160
MONTCALM CC.	32,979	850	15,572	16,557	0	0	0	0	0	1,103	7,850	18,667	0	5,357
MONTEREY PENINSULA COL.	10,000	0	10,000	0	0	0	0	0	0	10,000	0	0	0	0
MONTGOMERY COL.	84,003	3,371	81,736	0	0	1,760	0	1,760	0	54,125	0	31,000	0	0
MUSKINGUM AREA TECH. COL.	55,722	962	0	0	0	54,760	0	411	0	26,316	3	28,995	0	0
NEW MEXICO MILITARY INST.	1,429,000	104,000	16,000	601,000	0	0	0	853,003	1,000	0	600,000	174,000	0	0
NORTH DAKOTA ST. SCH. OF SCI.	81,015	100	38,920	0	7,100	31,676	0	18,979	0	58,136	0	4,500	0	0
NORTHAMPTON CO. CC.	130,903	85,913	13,043	1,070	0	28,279	2	5,330	0	64,311	0	32,097	0	7,207
NORTHEASTERN JC.	150,037	825	46,735	91,637	0	0	0	1,001	0	101,306	13,306	18,612	0	830
OLDS COL.	117,081	0	16,384	70,406	0	29,891	0	32,611	6,300	6,167	500	22,176	0	31,127
PADUCAH CC.	43,050	6,290	36,760	0	0	0	0	0	0	16,735	0	4,130	0	24,185
PARIS JC.	200,895	895	200,000	0	0	0	0	891	0	0	200,000	0	0	0
POLK CC.	174,112	34,268	140,044	0	0	0	3	2,370	0	26,602	12,623	132,317	0	0
POTOMAC ST. COL.	26,459	0	9,280	4,273	1,918	11,076	3	12,902	0	600	603	12,187	0	200
RANDOLPH TECH. COL.	66,018	1,013	36,172	0	0	28,833	0	795	650	11,016	33,907	11,500	0	0
RICHMOND TECH. COL.	31,676	3,732	2,599	25,050	295	0	0	0	0	20,126	0	3,550	0	0
ROCHESTER CC.	285,000	0	35,000	250,000	0	0	0	0	0	0	0	285,000	0	0
ROCK VALLEY COL.	89,220	0	89,220	0	0	0	0	0	0	28,778	45,442	15,091	0	669
SANDHILLS CC.	363,020	27,030	81,893	0	0	233,806	3	0	0	11,300	13,885	6,011	0	271,606
SHELBY ST. CC.	7,491	6,105	1,386	0	0	0	3	0	0	1,260	250	5,673	0	308
SOUTH GEORGIA COL.	66,166	38,529	11,000	10,318	0	18,027	12,503	2,626	650	22,736	30	36,335	0	3,971
SOUTHEASTERN [illegible] TECH. CC.	45,125	0	45,125	0	0	0	3	6,439	7,650	13,070	6,892	13,074	0	0
SOUTHSIDE VIRGINIA CC.	16,488	14,388	2,100	0	0	0	0	800	0	6,365	3	7,113	10	880
SOUTHWESTERN COL.	28,551	21,042	0	0	0	1,509	3	3	0	13,068	0	2,000	0	7,483
STARK TECH. COL.	21,934	771	7,013	11,699	0	300	0	218	0	1,390	1,066	10,375	903	0
STATE TECH. INST. AT MEMPHIS	7,082	822	6,260	0	0	0	3	200	0	622	286	500	0	5,386
SUNY-AGT COL.-DELHI	197,040	26,400	152,775	0	4,339	13,031	0	13,013	10,291	87,315	13,980	53,622	0	19,217
SUNY-DUTCHESS CC.	201,777	0	91,966	109,811	0	0	3	170	0	2,402	20,594	164,298	0	24,313
SUNY-JAMESTOWN CC.	1,997,768	112,485	54,630	0	930,653	903,000	3	0	0	1,556,233	37,015	0	0	2,100
SUNY-SCHENECTADY CO. CC.	23,133	0	5,850	8,183	0	9,203	3	0	0	8,698	0	11,765	100	2,610
TARRANT CO. JC.	131,200	0	101,200	3	0	30,000	3	0	0	30,700	60,500	40,000	0	0
TRITON COL.	36,650	46,000	0	0	0	10,654	0	0	0	0	0	0	0	30,650
TYLER JC.	887,675	118,822	457,683	311,173	3	0	0	0	0	637,105	105,700	84,970	0	56,900
UTAH TECH. COL. PROVO	168,365	12,536	18,499	137,233	0	0	3	0	0	9,717	0	146,052	0	6,696
UTAH TECH. COL. SALT LAKE	649,907	574,616	28,341	44,890	0	10,462	3	8,032	0	577,765	800	63,110	0	0
VALENCIA CC.	338,549	44,921	283,628	0	3	10,000	0	9,000	0	64,449	20,000	257,100	0	0
VERMONT TECH. COL.	3,690	93	0	0	0	3,600	0	90	0	3,600	0	0	0	0
WASH. ST. CC. DIST 17 OFFICE	289,239	12,959	34,966	30,589	0	142,705	3	3,102	0	138,362	1,000	61,965	0	6,230
WASHTENAW CC.	26,619	26,619	0	0	0	0	0	3	0	13,069	5,383	7,776	0	0
WESTERN PIEDMONT CC.	48,766	0	17,000	31,766	0	0	3	0	0	3,006	13,500	10,000	330	21,930
WILLIAM RAINEY HARPER COL.	76,462	13,979	34,483	28,003	0	0	3	3,900	0	10,862	3	39,463	0	16,237
WILLMAR CC.	15,200	0	15,200	0	0	0	0	0	0	0	15,200	0	0	0
WILSON CO. TECH. INST.	39,380	39,380	0	0	0	0	3	0	0	3,023	0	35,051	0	0
WISCONSIN CENTERS, U. OF	7,112	0	7,112	3	3	0	0	0	0	2,187	0	3,250	0	1,675

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0	0	6,000	6,000	20	383	106,283	0	0	0	0	0	NA	0	3,543	MI LAKESHORE TECH. INST.
NA	NA	NA	NA	NA	NA	67,012	75,000	250,000	23,000	0	0	32,868,928	137,139	7,913	OR LANE CC.
0	0	NA	0	3	0	0	0	0	0	0	0	NA	0	2,350	CN LETHBRIDGE CC.
0	0	9,771	9,771	327	3,130	5,683	348,953	0	0	11	2,303	12,026,097	1,414,223	7,173	OH LORAIN CO. CC.
75,000	0	10,000	0	0	0	0	25,000	0	0	0	0	6,169,000	1,288,000	4,000	WA LOWER COLUMBIA COL.
0	0	1,138	337	82	822	18,443	0	5,306	4,078	1	25	3,105,926	3,836	2,511	NC MAYLAND TECH. COL.
0	NA	NA	3,000	286	1,430	1,083	NA	NA	NA	NA	NA	100,982,674	16,059	37,709	FL MIAMI-DADE CC.
0	0	NA	0	0	0	0	0	0	0	0	0	3,290,467	0	7,006	NE MID PLAINS TECH. CC. AREA
0	0	10,030	0	0	0	0	0	0	0	0	0	15,647,250	0	7,708	SC MIDLANDS TECH. COL.
0	0	2,278	NA	12	389	45,180	0	0	0	2	400	6,846,732	NA	1,120	MN MINN.-U. OF.TECH. COL.-WASECA
0	0	NA	0	0	0	0	0	0	0	0	0	NA	0	9,000	CA MIRA COSTA COL.
0	0	NA	0	0	0	0	0	0	0	0	0	3,806,049	70,000	4,193	NC MITCHELL CC.
0	0	NA	1,036	32	4,444	6,340	0	0	0	0	0	7,031,731	943,959	3,050	MI MONROE CO. CC.
1,500	0	NA	0	0	0	0	12,500	0	0	0	0	1,238,027	15,607	1,389	MI MONTCALM CC.
0	0	NA	0	0	0	0	0	0	0	0	0	NA	0	7,317	CA MONTEREY PENINSULA COL.
0	0	0	0	0	0	0	89,015	560	0	9	985	66,339,300	0	30,316	MD MONTGOMERY COL.
0	0	2,572	NA	NA	411	35,728	0	2,100	0	0	0	NA	53,722	1,676	OH MUSKINGUM AREA TECH. COL.
0	0	20,000	10,000	990	850,000	850,000	0	0	0	0	0	NA	6,000,000	950	NM NEW MEXICO MILITARY INST.
0	0	NA	0	0	0	0	120,630	0	0	0	0	NA	0	3,565	ND NORTH DAKOTA ST. SCH. OF SCI.
0	0	NA	NA	5	153	30,332	0	0	8,187	6	333	9,096,093	161,636	6,100	PA NORTHAMPTON CO. CC.
91,487	0	7,649	2,350	39	1,003	1,393	10,678	3,736	6,400	0	0	3,337,170	0	1,292	CO NORTHEASTERN JC.
0	0	NA	0	0	0	0	0	0	313,610	0	0	NA	128,721	850	CN OLDS COL.
0	0	NA	0	0	0	0	0	0	0	1	1,575	3,359,876	877,221	2,030	KY PADUCAH CC.
0	0	NA	0	0	0	0	0	0	0	0	0	6,027,710	890,000	2,199	TX PARIS JC.
0	0	10,800	6,400	200	2,378	176,113	0	0	0	1	300	6,422,170	0	5,000	FL POLK CC.
0	0	10,376	10,376	728	5,700	13,066	0	0	0	6	350	3,111,323	0	1,068	WV POTOMAC ST. COL.
0	0	NA	0	0	0	0	0	0	0	1	100	NA	0	3,430	NC RANDOLPH TECH. COL.
6,300	6,300	NA	NA	NA	0	3,599	0	3,550	0	1	1,000	2,837,619	0	1,033	NC RICHMOND TECH. COL.
0	0	NA	0	0	0	0	0	0	0	0	0	7,327,285	0	2,870	MN ROCHESTER CC.
0	0	NA	0	0	0	0	0	18,961	23,397	3	150	6,385,317	0	11,287	IL ROCK VALLEY COL.
0	0	NA	0	0	0	363,621	0	0	0	0	0	[illegible]	1,233,730	4,041	NC SANDHILLS CC.
0	0	30,030	0	0	0	0	0	0	0	0	0	14,324,126	0	5,000	TN SHELBY ST. CC.
10,227	10,227	6,000	6,000	46	2,626	66,166	0	0	0	3	1,250	4,701,098	111,720	1,137	GA SOUTH GEORGIA COL.
0	0	NA	0	0	0	0	0	0	0	0	0	[illegible]	201,000	1,300	NE SOUTHEASTERN NEBR. TECH. CC.
0	0	2,200	2,200	11	300	16,300	0	0	0	0	0	3,636,177	0	1,070	VA SOUTHSIDE VIRGINIA CC.
0	3,000	NA	0	0	0	0	0	0	0	0	0	NA	36,300	11,087	CA SOUTHWESTERN COL.
0	0	NA	0	0	0	0	0	12,000	1,030	1	30	6,703,673	9,775	6,000	OH STARK TECH. COL.
0	0	0	0	0	0	0	160	500	3,700	0	0	19,009,309	0	6,700	TN STATE TECH. INST. AT MEMPHIS
0	0	18,062	18,656	561	18,893	94,085	21,625	0	61,133	41	3,000	NA	317,056	2,276	NY SUNY-AGT COL.-DELHI
0	0	NA	0	0	0	0	102,300	0	1,600	2	190	[illegible]	62,271	5,237	NY SUNY-DUTCHESS CC.
1,303,133	0	NA	0	0	0	0	0	0	0	0	0	8,320,212	1,378,996	3,295	NY SUNY-JAMESTOWN CC.
0	0	NA	0	0	0	0	0	8,100	0	0	0	6,327,672	38,023	3,663	NY SUNY-SCHENECTADY CO. CC.
0	0	NA	0	0	0	0	0	0	0	0	0	63,208,690	100,000	27,632	TX TARRANT CO. JC.
0	0	NA	0	0	0	0	300,000	600,000	700,000	0	0	NA	60,000	20,000	IL TRITON COL.
0	0	NA	0	0	0	0	0	11,170	0	0	0	[illegible]	0	7,800	TX TYLER JC.
0	0	NA	0	0	0	0	0	0	0	0	0	10,076,200	[illegible]	6,093	UT UTAH TECH. COL. PROVO
0	0	9,700	3,231	336	2,632	9,367	0	13,690	0	0	0	17,713,816	122,766	7,360	UT UTAH TECH. COL. SALT LAKE
0	0	NA	0	0	0	0	0	0	0	0	0	22,108,319	131,607	43,000	FL VALENCIA CC.
0	0	3,100	0	0	0	0	0	0	0	0	0	[illegible]	76,430	716	VT VERMONT TECH. COL.
0	0	3,293	3,203	253	3,902	66,066	407,662	61,031	2,000	0	0	NA	0	12,178	WA WASH. ST. CC. DIST 17 OFFICE
0	0	NA	0	0	0	0	0	0	0	6	780	17,382,700	0	8,351	MI WASHTENAW CC.
0	0	0	0	0	0	0	40,000	0	0	1	100	[illegible]	172,550	4,980	NC WESTERN PIEDMONT CC.
0	0	NA	0	0	0	0	6,000	9,000	13,000	0	0	NA	0	23,101	IL WILLIAM RAINEY HARPER COL.
0	0	NA	0	0	0	0	0	0	0	0	0	NA	0	700	MN WILLMAR CC.
0	0	NA	0	0	0	0	0	0	0	0	0	6,016,421	193,190	4,030	NC WILSON CO. TECH. INST.
0	0	NA	0	0	0	0	0	0	0	6	0	26,096,241	212,048	10,436	WI WISCONSIN CENTERS, U. OF

INDEPENDENT SECONDARY AND ELEMENTARY SCHOOLS (451)

[illegible]

200	NY ALBANY ACADEMY FOR GIRLS
274	NM ALBUQUERQUE ACADEMY
198	MS ALL SAINTS' EPISCOPAL SCHOOL
290	NY ALLEN-STEVENSON SCHOOL
690	NY ALLENDALE COLUMBIA SCHOOL
64	NJ AMERICAN BOYCHOIR SCHOOL
1,174	JP AMERICAN SCHOOL IN JAPAN
300	CA ARMY AND NAVY ACADEMY
217	NC ASHEVILLE SCHOOL
300	CA ATHENIAN SCHOOL
276	GA ATHENS ACADEMY
288	IL AVERY COONLEY SCHOOL
245	NY BALDWIN LEAGUE OF IND. SCH.
311	PA BALDWIN SCHOOL
396	MA BANCROFT SCHOOL
440	MO BARSTOW SCHOOL
484	TN BAYLOR SCHOOL
383	MA BEAVER COUNTRY DAY SCHOOL
171	MA BELMONT DAY SCHOOL
483	MA BELMONT HILL SCHOOL
387	FL BENJAMIN SCHOOL
730	FL BERKELEY PREP. SCHOOL
487	MA BERKSHIRE SCHOOL
1,491	IN BISHOP NOLL INSTITUTE
342	NJ BLAIR ACADEMY
1,116	MN BLAKE SCHOOLS
229	VA BLUE RIDGE SCHOOL
750	FL BOLLES SCHOOL
730	CN BRANKSOME HALL
633	NY BREARLEY SCHOOL
321	NH BREWSTER ACADEMY
159	ME BRIDGTON ACADEMY
345	TX [illegible] SCHOOL
185	MA [illegible] DAY SCHOOL
313	MA [illegible] SCHOOL
273	MA [illegible] SCHOOL
216	NY [illegible] SCHOOL
676	MD [illegible] SCHOOL
943	PA [illegible]
170	PA [illegible] FRIENDS SCHOOL
680	CA BUCKLEY SCHOOL
367	NY BUCKLEY SCHOOL
175	NY BUFFALO SEMINARY
310	WA BUSH SCHOOL
366	MA CAMBRIDGE SCHOOL
473	CA CAMPBELL HALL
296	IN CANTERBURY SCHOOL
160	MA CAPE COD ACADEMY
420	VA CAPE HENRY COLLEGIATE SCHOOL
142	NH CARDIGAN MOUNTAIN SCHOOL
1,048	OH [illegible] SCHOOL
330	CA CASTILLEJA SCHOOL
236	CA CATE SCHOOL
790	NY CATHOLIC CENTRAL HIGH SCHOOL
321	OR CATLIN GABEL SCHOOL
630	CA CHADWICK SCHOOL
423	CA CHANDLER SCHOOL

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INDEPENDENT SECONDARY AND ELEMENTARY SCHOOLS (CONT.)

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0	1,000	2,090	2,090	150	15,505	76,066	0	0	0	10	3,000	1,716,960	16,390	160	MA CHAPEL HILL-CHAUNCY HALL SCH.
0	0	1,000	0	2	60	2,001	1,500	0	2,100	3	1,952	912,390	360,066	232	NJ CHAPIN SCHOOL
31,097	0	3,140	2,063	1,219	283,068	567,677	0	0	0	60	36,789	6,087,100	9,000,000	600	NY CHAPIN SCHOOL
0	0	669	669	126	16,623	165,321	0	0	0	0	3,000	2,981,271	1,060,079	367	WA CHARLES WRIGHT ACADEMY
36,000	0	3,089	2,614	1,150	166,150	337,305	0	0	27,320	31	11,744	1,770,013	3,436,142	140	VA CHATHAM HALL
0	0	4,000	3,453	384	76,009	110,570	0	0	0	0	3,030	2,756,080	271,036	300	CT CHESHIRE ACADEMY
0	0	1,000	1,000	582	66,636	105,023	0	0	0	0	0	2,627,693	6,011,616	470	PA CHESTNUT HILL ACADEMY
77,600	0	160	160	11	900	152,900	0	0	0	2	475	1,194,080	1,100,030	220	IL CHICAGO JUNIOR SCHOOL
36,000	10,736	10,000	9,950	5,000	715,662	1,086,106	0	0	36,968	312	76,736	12,756,293	29,032,000	900	CT CHOATE ROSEMARY HALL
0	0	1,320	1,320	695	136,731	300,066	0	0	2,316	16	2,040	1,471,000	1,666,678	155	NC CHRIST SCHOOL
6,213	0	1,988	0	0	38,132	637,596	0	0	0	62	3,67.	1,061,066	0	371	PA CHRISTOPHER DOCK MENNONITE H.S.
0	0	1,316	1,673	452	63,786	232,086	0	0	0	15	3,119	3,621,195	3,392,968	787	OH CINCINNATI COUNTRY DAY SCHOOL
0	0	568	496	66	3,756	91,201	0	0	0	0	4,225	1,262,169	39,629	243	CA COLLEGE PREPARATORY SCHOOL
1,300	0	2,782	2,782	806	56,706	303,619	0	0	0	76	10,573	6,793,192	0	1,236	VA COLLEGIATE SCHOOLS
303,000	0	1,568	1,506	907	66,011	256,670	0	1,500	0	21	7,650	2,950,196	2,838,723	662	CO COLORADO ACADEMY
0	0	1,333	1,091	881	65,605	218,392	271	0	23,936	2	430	1,336,216	40,066	107	CO COLORADO ROCKY MOUNTAIN SCHOOL
0	0	2,000	2,000	613	30,253	136,697	0	0	0	28	4,063	3,062,600	66,230	900	NY COLUMBIA GRAMMAR & PREP SCHOOL
0	0	800	800	366	13,690	265,921	0	0	0	16	3,935	66	1,006,976	623	OH COLUMBUS ACADEMY
6,320	0	3,162	3,160	895	96,936	336,898	0	0	9,060	13	8,091	2,127,080	5,100,000	607	OH COLUMBUS SCHOOL FOR GIRLS
2,000	0	1,673	1,330	937	37,460	103,780	230	0	7,675	0	0	1,306,910	768,756	233	MD COMMUNITY SCHOOL
21,013	0	2,307	2,230	1,110	136,603	336,743	29,580	0	66	69	16,335	3,360,293	1,610,930	319	MA CONCORD ACADEMY
0	0	922	875	567	6,020	38,030	2,000	0	4,440	13	1,675	1,066,359	0	246	MD CONNELLY SCH. OF HOLY CHILD
0	0	1,480	1,350	435	36,657	136,997	0	0	0	36	10,790	1,966,062	060,636	340	CT CONVENT OF THE SACRED HEART
0	0	1,050	1,030	663	32,058	177,387	0	0	71,390	0	0	3,066,676	323,623	636	NY CONVENT OF THE SACRED HEART
3,486	0	1,600	1,600	483	26,982	128,575	16,000	0	22,000	10	4,483	1,253,076	616,075	326	MN CONVENT OF THE VISITATION SCH.
0	0	1,150	1,130	321	10,378	112,963	1,550	0	0	11	2,750	2,059,060	380,990	330	MO C.D. SCH. OF THE SACRED HEART
0	0	1,440	1,440	170	11,962	306,201	25,000	66	1,695	66	11,373	66	0	700	CA CRESPI CARMELITE HIGH SCHOOL
322,998	0	9,100	9,100	1,403	567,136	1,022,907	10,026	366,580	636,995	77	33,018	9,366,231	27,021,000	730	IN CULVER ACADEMIES
1,953	66	4,636	4,000	390	133,009	165,335	0	0	22,763	61	3,582	3,368,213	1,030,238	330	MA CUSHING ACADEMY
763,690	926	4,221	3,073	1,907	211,401	326,101	66	66	66	88	17,336	3,031,131	3,766,276	619	MA DANA HALL SCHOOL
0	0	3,000	3,000	1,207	116,732	228,872	0	0	15,036	3	1,393	3,061,002	1,926,498	930	GA DARLINGTON SCHOOL
0	0	1,380	1,433	386	63,096	56,356	0	0	6,000	19	8,070	1,066,603	0	130	NY DARROW SCHOOL
0	0	712	712	362	4,481	34,216	0	0	1,013	4	765	931,210	167,869	213	MA DEDHAM COUNTRY DAY SCHOOL
78,101	5,287	8,584	8,306	4,382	1,087,713	1,339,676	0	0	0	238	64,219	3,276,133	30,671,000	566	MA DEERFIELD ACADEMY
0	0	373	373	50	1,098	38,467	0	3,000	0	3	323	1,306,893	96,161	233	NH DERRYFIELD SCHOOL
0	0	1,225	900	532	15,780	128,566	0	6,300	1,000	18	2,375	7,033,651	308,775	1,169	MI DETROIT COUNTRY DAY SCHOOL
0	3	971	900	223	66,780	94,338	0	0	0	13	6,140	913,603	136,962	83	NH DUBLIN SCHOOL
0	0	452	303	100	3,480	36,983	0	0	2,693	0	0	1,145,922	120,000	130	CA DUNN SCHOOL
3	0	3,000	1,300	118	0,310	86,962	0	0	0	17	6,400	3,006,361	2,016,367	716	NC DURHAM ACADEMY
3	0	3,969	3,969	706	35,065	625,353	0	0	16,316	31	8,016	3,976,302	100,732	660	NJ DWIGHT-ENGLEWOOD SCHOOL
3	0	2,582	2,468	352	91,751	326,000	66	66	9,673	10	30,613	1,331,600	3,393,353	265	MA EAGLEBROOK SCHOOL
0	0	775	706	280	11,797	86,866	1,740	5,320	11,695	17	6,477	1,337,213	320,000	273	NY EAST WOODS SCHOOL
0	0	973	975	323	23,520	367,620	0	0	3,000	26	3,025	1,675,919	225,249	296	IL ELGIN ACADEMY
6,731	3	1,001	1,093	601	61,283	136,829	0	0	0	31	6,180	1,060,717	6,052,658	620	PA ELLIS SCHOOL
0	0	193	193	33	1,065	79,706	0	0	0	1	230	66	1,063,179	272	NY ELMWOOD FRANKLIN SCHOOL
232,330	46,606	6,391	6,931	2,106	327,315	916,298	0	0	25,063	106	23,319	1,328,670	15,748,911	311	NY EMMA WILLARD SCHOOL
0	3	1,329	763	361	30,751	192,272	950	66	700	2	375	1,308,316	1,165,713	650	TN ENSWORTH SCHOOL
56,077	3	2,375	2,062	1,871	109,664	206,006	66	66	2,500	69	13,106	6,129,736	1,657,013	989	PA EPISCOPAL ACADEMY
11,065	3	6,607	3,579	2,093	625,975	621,367	0	0	0	0	0	3,853,939	10,091,383	290	VA EPISCOPAL HIGH SCHOOL
0	0	3,916	2,502	1,001	173,361	292,316	0	0	0	67	16,290	2,427,000	6,956,800	230	CT ETHEL WALKER SCHOOL
56,900	0	6,396	4,736	1,000	131,691	668,367	66	66	7,500	65	9,333	8,006,286	8,667,927	1,697	NY ETHICAL CULTURE SCHOOLS
0	0	372	372	69	6,673	30,906	0	0	0	7	2,973	756,575	36,056	183	NJ FAR BROOK SCHOOL
0	0	873	130	28	963	69,283	0	0	0	0	0	961,369	630,696	239	NJ FAR HILLS COUNTRY DAY SCHOOL
0	0	1,900	1,900	632	63,061	330,976	0	0	0	0	0	2,728,063	656,066	339	MA FAY SCHOOL
0	0	1,025	550	20	3,775	69,066	0	0	4,066	1	330	913,500	13,080	90	AZ FENSTER SCH. OF SO. ARIZONA
0	0	3,012	2,602	176	62,620	83,955	0	0	0	0	0	66	0	363	MA FESSENDEN SCHOOL
0	0	400	38	1	25	22,040	0	0	0	2	150	1,837,577	0	300	NY FLEMING SCHOOL

INDEPENDENT SECONDARY AND ELEMENTARY SCHOOLS (CONT.)

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3,083	0	2,397	2,397	562	38,629	187,612	0	0	9,246	10	1,500	4,411,721	1,170,000	690	VA FORK UNION MILITARY ACADEMY
0	0	440	267	185	3,303	80,981	0	0	0	43	70,073	2,144,221	17,027	605	NC FORSYTH COUNTRY DAY SCHOOL
0	0	734	717	162	8,759	227,391	0	0	0	0	0	3,008,318	2,306,998	897	TX FORT WORTH COUNTRY DAY SCHOOL
0	0	1,093	1,072	609	197,804	395,777	0	0	13,000	3	450	2,373,866	1,463,264	220	CO FOUNTAIN VALLEY SCHOOL
0	0	370	370	87	693	23,030	0	0	0	1	3,430	NA	495,482	143	PA FOX CHAPEL COUNTRY DAY SCHOOL
0	0	2,085	1,938	647	146,605	237,075	0	0	NA	0	0	3,809,230	7,383,476	230	VA FOXCROFT SCHOOL
0	0	1,380	1,320	44	2,099	66,836	3,390	0	2,449	0	0	3,069,839	1,833,440	779	CA FRANCIS W. PARKER SCHOOL
0	0	2,018	2,116	321	44,018	367,953	0	0	0	32	19,393	3,461,816	2,099,191	760	IL FRANCIS W. PARKER SCHOOL
461,900	NA	2,722	1,000	628	28,011	383,265	0	0	0	29	9,370	4,900,000	1,861,500	667	NY FRIENDS ACADEMY
0	67,439	2,409	2,409	600	34,907	131,000	0	0	32,900	0	0	3,034,637	832,216	895	MD FRIENDS SCHOOL
0	0	NA	283	81	2,398	35,988	0	0	0	7	1,100	393,400	257,823	135	PA FRIENDS SCHOOL
2,390	0	2,085	2,085	628	29,398	78,982	0	0	NA	18	3,360	1,713,881	1,039,386	614	PA FRIENDS SELECT SCHOOL
0	0	1,771	1,771	136	11,813	48,920	0	0	3,000	30	5,903	3,876,328	193,796	560	NY FRIENDS SEMINARY
6,000	0	3,263	3,057	1,379	94,360	242,067	0	0	NA	32	8,131	2,900,924	1,822,609	633	PA FRIENDS' CENTRAL SCHOOL
7,000	0	2,740	2,331	802	183,077	200,628	0	0	64,144	31	12,360	NA	1,448,000	683	MD GARRISON FOREST SCHOOL
0	100,334	6,001	6,001	3,007	283,702	412,240	0	0	NA	80	18,726	5,710,731	7,200,000	530	PA GEORGE SCHOOL
18,313	12,463	2,876	2,876	444	91,734	230,363	0	0	0	9	2,400	NA	1,006,440	390	MD GEORGETOWN PREPARATORY SCHOOL
7,000	0	3,386	2,336	1,910	131,464	250,226	0	3,091	12,089	80	11,944	4,409,369	3,337,495	887	PA GERMANTOWN FRIENDS SCHOOL
0	0	400	380	36	3,304	30,071	0	0	1,238	1	300	278,000	325,000	180	MD GIBSON ISLAND COUNTRY SCHOOL
0	0	1,487	1,276	138	3,788	84,782	0	0	0	16	3,975	2,844,693	807,637	336	NJ GILL/ST. BERNARD'S SCHOOL
122,909	0	4,080	3,315	1,726	194,572	291,153	4,237	1,304	19,613	65	12,003	3,238,943	9,709,383	906	MD GILMAN SCHOOL
0	0	1,940	1,475	309	91,579	327,182	6,380	0	10,760	20	16,335	2,982,173	1,308,777	497	OH GILMOUR ACADEMY
0	0	3,621	3,073	1,385	79,190	183,763	NA	NA	NA	0	0	1,964,337	2,362,644	630	TN GIRLS' PREPARATORY SCHOOL
0	0	330	309	37	2,053	31,884	0	0	2,180	0	0	982,250	5,077	290	MD GLENELG COUNTRY SCHOOL
0	0	340	340	30	487	78,163	0	0	13,480	0	825	482,822	914,744	353	VI GOOD HOPE SCHOOL
0	0	2,010	2,790	782	42,480	118,968	3,099	3,032	3,425	14	2,100	2,780,873	2,343,778	202	ME GOULD ACADEMY
0	0	4,123	3,036	1,417	190,290	369,218	80,000	0	3,300	71	29,190	3,448,000	5,308,000	340	MA GOVERNOR DUMMER ACADEMY
0	0	1,200	1,200	105	11,471	304,300	0	0	1,722	0	0	3,400,873	3,936,063	565	CO GRALAND COUNTRY DAY SCHOOL
0	0	376	277	99	1,773	40,323	0	0	0	3	800	407,799	400,000	182	OH GRAND RIVER ACADEMY
10,000	0	470	336	96	2,370	24,186	0	0	0	0	0	NA	35,000	170	AZ GREEN FIELDS C. D. SCHOOL
0	0	1,191	835	125	11,423	334,783	4,000	1,030	11,555	82	12,310	4,473,115	372,172	1,097	TX GREENHILL SCHOOL
0	0	1,040	700	40	4,135	84,300	0	0	6,047	0	0	2,344,884	778,000	436	CT GREENS FARMS ACADEMY
0	0	1,030	1,030	331	27,734	218,804	0	0	0	0	0	NA	0	587	CT GREENWICH ACADEMY
0	0	2,275	2,000	143	38,301	303,073	0	0	0	61	27,713	NA	3,944,000	790	CT GREENWICH COUNTRY DAY SCHOOL
300	30,636	2,314	2,195	1,584	483,299	679,737	0	0	10,000	184	32,000	6,043,173	29,117,510	313	MA GROTON SCHOOL
38,083	0	2,261	2,235	595	80,182	800,133	0	0	486	36	13,433	2,330,134	1,930,266	286	CT GUNNERY
0	0	400	470	75	4,916	54,444	0	0	7,900	2	230	387,000	77,167	83	[illegible]
0	0	387	311	29	690	63,676	0	0	0	0	7,363	330,000	108,300	182	CT HAMMONASSET SCHOOL
0	0	NA	0	0	0	0	0	0	0	0	0	871,162	340,000	360	TN HARDING ACADEMY
1,000	0	3,433	0	0	29,205	261,335	0	0	4,333	21	11,430	2,348,972	0	376	VA HARGRAVE MILITARY ACADEMY
13,000	0	1,273	1,212	380	17,409	112,999	NA	NA	NA	42	1,990	2,219,300	750,000	432	NY HARLEY SCHOOL
0	0	1,500	1,300	127	19,966	48,482	0	0	0	3	225	1,988,626	491,910	373	PA HARRISBURG ACADEMY
0	0	4,147	2,816	330	31,403	271,424	NA	0	NA	21	11,992	4,112,823	3,477,177	881	CA HARVARD SCHOOL
0	0	1,530	1,350	60	4,000	34,381	0	0	0	17	7,320	1,384,336	65,340	274	NY HARVEY SCHOOL
64,214	3	3,082	3,082	1,135	134,908	233,296	0	0	6,115	41	18,708	2,390,453	4,240,734	479	OH HATHAWAY BROWN SCHOOL
3	0	1,373	1,160	399	23,772	234,403	0	0	0	0	1,136	NA	4,300,000	376	HI HAWAII PREPARATORY ACADEMY
0	0	425	425	26	970	61,449	0	0	0	7	2,391	NA	100,000	235	HI HAWAII SCHOOL FOR GIRLS
353,221	0	2,094	1,941	986	186,935	319,672	0	0	0	79	31,482	5,018,307	5,723,597	818	OH HAWKEN SCHOOL
0	0	2,230	2,130	239	17,497	76,384	0	0	NA	4	490	2,337,131	834,230	334	CA HEAD-ROYCE SCHOOL
6,435	0	3,783	3,783	909	76,231	122,383	0	0	2,000	43	7,233	2,328,817	943,480	260	ME HEBRON ACADEMY
3	0	1,100	NA	NA	0	8,430	0	0	0	0	0	2,062,909	217,367	881	OK HERITAGE HALL
224,103	NA	7,044	4,040	2,333	421,013	831,484	0	0	0	95	44,314	3,230,110	16,304,400	585	PA HILL SCHOOL
0	0	400	300	12	470	32,262	0	0	0	0	0	886,637	37,128	280	CA HILLBROOK SCHOOL
0	0	4,400	4,400	811	168,100	343,038	0	0	0	21	13,346	4,880,129	9,316,282	836	TX HOCKADAY SCHOOL
2,303	3	1,800	1,800	838	88,376	250,753	0	2,140	10,000	62	6,232	2,118,131	1,990,000	246	NH HOLDERNESS SCHOOL
0	0	1,349	1,349	97	4,008	283,370	0	0	0	11	4,905	3,838,069	16,738,847	995	OK HOLLAND HALL SCHOOL
0	3	6,100	6,100	1,395	107,996	193,413	0	0	0	50	19,400	3,896,800	54,381	1,397	LA HOLY CROSS SCHOOL

INDEPENDENT SECONDARY AND ELEMENTARY SCHOOLS (CONT.)

	[illegible]	[illegible]		[illegible]				[illegible]						
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HOPKINS SCHOOL	698,067	160,033	17,482	214,400	0	3,126	0	136,513	101,456	31,265	170,797	39,290	0	16,766
HORACE MANN-BARNARD SCHOOL	1,265,306	273,331	20,400	3,400	907,383	36,752	0	521,451	599,266	41,529	73,000	18,140	0	0
HOTCHKISS SCHOOL	3,623,438	1,304,064	40,904	911,773	1,231,104	985,623	39,000	2,443,104	325,899	462,027	291,904	117,096	0	0
HOWE MILITARY SCHOOL	783,191	100,491	123,000	117,230	0	440,430	0	103,190	16,199	128,067	471,253	61,330	0	1,150
HUTCHISON SCHOOL	339,703	43,193	1,276	291,034	0	4,200	0	86,540	157,044	64,752	41,750	7,575	0	0
HYDE SCHOOL	100,709	75,031	14,333	0	11,223	0	0	7,983	52,779	34,731	5,050	150	0	94
INDIAN SPRINGS SCHOOL	179,491	0	0	0	140,577	38,914	0	57,932	27,368	48,461	11,650	34,200	0	0
IOLANI SCHOOL	262,000	151,120	0	55,032	0	55,908	0	59,471	69,153	66,586	34,300	14,300	0	2,050
ISIDORE NEWMAN SCHOOL	954,567	384,433	14,227	382,070	68,029	71,706	0	206,477	103,304	9,883	133,030	91,340	0	30,771
JOHN BURROUGHS SCHOOL	1,204,513	321,045	0	673,313	74,244	129,137	0	399,131	250,533	137,034	369,000	115,763	0	25,000
JOHN THOMAS DYE SCHOOL	151,451	120,101	13,290	0	0	16,100	0	323	108,774	4,300	35,400	230	0	0
JULIUS T. WRIGHT SCHOOL	223,473	97,471	0	127,004	0	0	0	1,744	218,734	0	0	5,025	0	0
KATHARINE BRANSON-MT.TAMALPAIS	493,095	150,401	65,173	195,727	0	77,594	0	38,163	109,294	349,100	10,332	0	0	0
KEITH COUNTRY DAY SCHOOL	164,301	120,354	43,027	0	0	0	0	86,497	33,855	18,084	3,935	44,127	0	45,143
KENT PLACE SCHOOL	919,402	177,725	30,984	301,009	0	97,400	4,000	144,169	239,142	216,091	212,000	74,100	0	12,000
KENT SCHOOL	787,773	49,467	380,336	318,000	0	0	0	354,245	289,408	61,023	20,000	70,130	0	74,130
KENT SCHOOL	416,484	307,054	31,300	18,750	2,300	57,440	5,000	44,063	193,444	73,444	35,004	9,400	0	29,094
KENTS HILL SCHOOL	163,300	136,300	0	0	0	25,000	0	34,125	41,467	40,748	25,000	3,900	34,420	0
KENTUCKY COUNTRY DAY SCHOOL	167,000	90,254	36,072	25,149	493	14,400	0	3,700	33,000	12,726	11,542	29,343	0	57,937
KEY SCHOOL	225,772	58,409	4,462	164,425	0	6,256	0	440	188,223	12,749	3,000	1,125	1,300	17,035
KIMBALL UNION ACADEMY	353,423	324,098	0	0	0	29,373	0	222,344	92,954	31,738	0	40,027	0	0
KING SCHOOL	100,582	79,582	0	0	21,000	0	0	6,534	72,453	1,035	850	16,920	0	0
KINGSWOOD-OXFORD SCHOOL	654,807	424,427	40,750	28,952	53,940	97,000	0	303,004	106,051	83,359	23,050	52,931	0	23,388
KINKAID SCHOOL	2,784,367	513,427	413,409	153,337	1,449,020	179,944	0	1,734,196	343,427	293,738	174,000	113,647	0	46,419
KISKIMINETAS SPRINGS SCHOOL	2,044,484	137,794	30,045	1,378,329	0	130,000	0	1,536,077	50,173	6,140	281,448	[illegible]	0	0
LAKE FOREST ACADEMY-FERRY HALL	746,483	282,414	75,744	340,913	19,157	84,633	0	447,419	42,430	86,914	112,013	18,455	0	58,137
LAKE FOREST COUNTRY DAY SCHOOL	300,131	184,122	0	3,000	103,189	11,048	0	34,310	194,903	27,274	27,973	3,457	0	0
LAKE RIDGE ACADEMY	193,173	112,453	38,998	44,322	0	4,473	0	3,253	129,598	38,791	10,550	10,194	0	0
LAKESIDE SCHOOL	381,423	184,132	106,959	93,474	10,518	82,360	0	145,116	113,902	110,473	26,900	63,700	0	135,358
LAMPLIGHTER SCHOOL	134,211	134,211	0	0	0	0	0	350	103,465	30,774	17,000	2,420	0	0
LANCASTER COUNTRY DAY SCHOOL	604,900	61,679	7,395	472,234	63,600	0	0	112,138	122,908	235,944	117,300	16,398	0	0
LANDON SCHOOL	338,901	231,360	74,167	185,403	0	87,395	0	101,187	167,917	47,436	97,233	15,382	0	73,158
LANGLEY SCHOOL	60,433	54,823	0	5,000	0	0	0	0	56,803	0	2,000	730	0	0
LATIN SCHOOL OF CHICAGO	491,851	239,361	237,401	0	2,190	6,430	0	44,787	369,908	15,128	12,861	16,173	0	133,000
LAUREL SCHOOL	679,294	332,994	31,333	41,910	153,146	138,929	0	438,332	313,203		91,300	22,239	0	0
LAWRENCE ACADEMY AT GROTON	265,378	118,373	133,901	14,027	0	4,277	0	47,210	130,319	31,002	21,450	16,009	0	0
LAWRENCE COUNTRY DAY SCHOOL	82,483	80,973	0	0	0	1,451	0	30,187	16,016	24,117	0	12,000	0	0
LAWRENCEVILLE SCHOOL	4,143,777	1,214,993	15,000	2,913,782	0	0	0	3,022,367	230,842	13,439	704,335	85,914	0	0
LEELANAU SCHOOL	638,230	462,111	0	174,239	0	0	0	9,779	57,727	257,300	0	313,444	0	0
LEXINGTON SCHOOL	133,306	133,306	0		0	0	0	0	128,481	3,125			0	0
LINCOLN SCHOOL	605,763	177,273	7,476	305,291	59,114	36,649	0	237,574	133,389	12,235	70,645	12,940	1,700	0
LINDLEY SCHOOL	836,431	97,425	0	0	739,006	0	0	170,382	96,360	209,820	133,500	62,930	0	164,500
LODGE SCHOOL	398,225	286,145	0	112,080	0	0	0	0	0	113,367	139,271	141,318	0	4,277
LOOMIS CHAFFEE SCHOOL	1,140,485	407,303	109,130	0	0	623,772	0	846,534	141,187	19,796	135,038	37,044	0	0
LOUDOUN COUNTRY DAY SCHOOL	70,738	64,951	100	0	0	3,273	0	403	19,579	7,493	43,191		0	0
LOUISE S. MCGEHEE SCHOOL	872,009	132,476	0	740,533	0	0	0	63,068	202,131	487,068	0	1,970	0	0
LOUISVILLE COLLEGIATE SCHOOL	309,991	125,760	11,204	291,307	6,020	0	0	44,009	74,830	37,498	23,168	176,333	0	10,079
LOVETT SCHOOL	630,522	342,429	0	302,403	35,478	34,212	0	130,764	167,778	178,424	127,317	11,151	0	40,404
LOW-HEYWOOD THOMAS SCHOOL	182,974	103,290	100	23,300	54,064	300	0	17,490	121,701	7,309	10,000	26,305	0	0
LOYOLA ACADEMY	1,441,492	1,047,144	9,008	114,413	243,279	231,434	0	427,314	816,087	173,264	75,000	14,445	130,502	0
LOYOLA SCHOOL	293,448	293,448	0	0	0	0	0	37,080	31,373	25,190	0	0	138,135	63,190
MADEIRA SCHOOL	1,071,445	412,122	119,139	307,296	455,526	177,362	58,383	1,232,963	385,226	10,594	59,283	3,400	0	0
MALVERN PREPARATORY SCHOOL	400,460	292,460	4,000	99,300	0	5,000	0	60,079	243,701	48,998	6,000	20,913	1,073	12,025
MARIST SCHOOL	67,110	67,110	0	0	0	0	0	1,485	52,465	1,698	7,880	3,070	0	0
MARION HEIGHTS ACADEMY	254,133	137,134	36,013	40,086	0	41,500	0	14,272	3,875	114,396	32,000	73,714	4,700	1,676
MARIN ACADEMY	219,201	128,064	59,842	0	0	39,355	0	1,233	124,219	54,337	39,003	2,475	0	0

0	0	4,818	4,818	920	78,971	157,903	0	3,660	0	43	11,200	3,303,734	1,080,257	596	CT HOPKINS SCHOOL
0	0	4,310	3,400	1,067	133,963	275,331	0	0	12,100	29	18,140	6,905,377	3,496,712	1,640	NY HORACE MANN-BARNARD SCHOOL
691,409	17,963	4,101	0	2,911	906,112	1,304,004	0	0	0	239	101,796	7,027,432	43,049,949	327	CT HOTCHKISS SCHOOL
131,000	0	4,000	3,300	601	57,990	100,493	0	0	0	9	1,100	NA	18,313,300	195	IN HOWE MILITARY SCHOOL
0	0	1,700	1,400	199	18,305	43,995	0	0	0	4	775	1,721,256	143,297	705	TN HUTCHISON SCHOOL
0	0	697	484	88	7,989	75,263	0	0	4,752	0	0	1,000,400	15,000	179	ME HYDE SCHOOL
0	NA	1,882	NA	291	57,932	179,491	0	0	0	13	8,930	1,162,420	3,915,922	225	AL INDIAN SPRINGS SCHOOL
3,361	0	4,113	4,113	606	59,671	262,088	0	0	0	79	80,080	7,001,049	27,365,610	1,690	HI IOLANI SCHOOL
380	0	4,280	3,450	909	113,160	328,608	0	0	0	16	18,083	5,102,604	1,621,379	1,176	LA ISIDORE NEWMAN SCHOOL
80,000	0	4,039	3,914	1,703	300,927	525,015	0	0	5,013	48	15,434	3,204,355	4,821,072	598	MO JOHN BURROUGHS SCHOOL
3,000	0	NA	NA	2	525	131,631	0	0	1,201	1	200	1,501,713	1,996,665	323	CA JOHN THOMAS DYE SCHOOL
0	0	763	763	67	1,744	97,671	0	0	0	0	0	1,516,266	140,000	620	MS JULIUS T. WRIGHT SCHOOL
0	0	3,679	1,963	388	30,165	108,400	0	0	0	11	4,000	2,337,022	976,637	300	CA KATHARINE BRANSON-MT.TAMALPAIS
0	0	888	196	38	2,340	31,752	0	0	0	0	0	NA	0	276	IL KEITH COUNTRY DAY SCHOOL
0	0	2,000	2,000	691	33,527	177,625	0	0	0	0	0	2,444,206	1,316,287	494	NJ KENT PLACE SCHOOL
7,000	0	4,852	4,752	1,830	265,993	577,773	0	0	60,677	119	63,639	7,500,009	6,707,892	640	CT KENT SCHOOL
0	0	2,400	2,400	347	32,905	336,906	0	0	NA	13	3,400	3,204,300	1,313,000	910	MD KENT SCHOOL
0	0	3,029	3,029	443	26,125	138,300	0	0	0	0	0	NA	934,163	242	ME KENTS HILL SCHOOL
0	0	1,300	1,300	75	2,930	121,031	150	0	4,900	12	3,300	2,506,075	760,000	750	KY KENTUCKY COUNTRY DAY SCHOOL
0	0	300	0	0	0	33,004	0	0	0	0	0	1,400,029	6,048	308	MD KEY SCHOOL
0	16,000	3,400	2,963	1,482	190,916	336,018	0	0	16,366	33	13,033	3,033,931	3,303,191	265	NH KIMBALL UNION ACADEMY
0	0	730	730	136	8,526	79,302	0	0	0	67	16,900	NA	120,000	308	CT KING SCHOOL
11,000	NA	6,162	6,000	1,344	336,117	626,627	0	0	NA	0	0	3,216,000	1,912,026	815	CT KINGSWOOD-OXFORD SCHOOL
0	0	2,000	2,000	840	290,343	927,036	4,000	0	65,065	25	32,300	6,136,000	11,282,021	1,216	TX KINKAID SCHOOL
0	0	3,311	3,300	954	109,360	166,359	15,300	3,000	1,367	38	7,306	2,440,957	3,997,387	247	PA KISKIMINETAS SPRINGS SCHOOL
16,137	0	3,833	4,484	1,250	137,094	336,388	0	0	21,125	44	11,253	3,000,713	963,013	267	IL LAKE FOREST ACADEMY-FERRY HALL
63,323	0	1,300	1,300	175	49,696	186,122	823,966	0	11,418	16	2,487	1,876,619	2,762,907	609	IL LAKE FOREST COUNTRY DAY SCHOOL
0	0	300	237	36	2,935	143,383	21,000	0	2,300	8	2,190	1,302,216	409,466	306	OH LAKE RIDGE ACADEMY
3,000	0	3,733	3,570	962	112,388	395,671	0	2,575	29,460	26	8,330	4,324,455	3,211,765	635	WA LAKESIDE SCHOOL
0	0	NA	0	2	350	154,211	0	0	0	3	2,400	1,342,732	190,000	477	TX LAMPLIGHTER SCHOOL
50,000	0	990	847	395	17,485	60,076	0	1,465	3,524	24	9,705	1,248,823	952,065	389	PA LANCASTER COUNTRY DAY SCHOOL
0	0	3,744	1,913	870	65,763	253,368	0	0	NA	1	10,000	3,996,356	2,161,127	390	MD LANDON SCHOOL
0	0	297	NA	1	300	54,833	0	0	0	0	0	1,320,033	35,719	432	VA LANGLEY SCHOOL
0	0	3,300	30	20	16,007	316,361	0	0	26,687	22	10,025	4,362,460	434,185	916	IL LATIN SCHOOL OF CHICAGO
81,997	0	3,136	3,130	1,336	176,040	293,430	0	3,735	22,700	69	21,034	2,958,036	1,000,000	329	OH LAUREL SCHOOL
0	0	3,380	3,032	677	45,613	382,330	0	0	0	0	0	3,229,301	1,390,106	309	MA LAWRENCE ACADEMY AT GROTON
0	0	860	860	300	23,303	63,220	0	0	0	22	6,670	773,736	484,621	130	NY LAWRENCE COUNTRY DAY SCHOOL
0	0	10,330	10,300	6,091	899,482	1,331,996	0	0	0	0	0	NA	60,972,905	632	NJ LAWRENCEVILLE SCHOOL
96,000	0	1,376	1,376	53	9,779	9,779	NA	NA	63,939	3	0	NA	80,000	89	MI LEELANAU SCHOOL
0	0	300	80	NA	0	133,006	0	0	0	0	0	1,382,909	15,612	644	KY LEXINGTON SCHOOL
1,000	0	2,671	2,644	1,096	83,162	184,769	1,320	1,750	6,039	35	4,196	2,295,526	1,131,878	446	RI LINCOLN SCHOOL
0	0	2,000	2,000	344	68,397	97,025	0	400	2,300	0	0	1,791,322	2,916,764	338	WV LINSLY SCHOOL
0	0	0	0	0	0	0	0	0	0	0	0	385,968	0	38	MO LOGOS SCHOOL
3	0	7,030	6,431	2,096	201,913	916,633	0	0	0	265	35,662	6,487,403	12,436,378	699	CT LOOMIS CHAFFEE SCHOOL
0	0	296	279	10	445	67,455	0	0	0	0	0	NA	3,275	127	VA LOUDOUN COUNTRY DAY SCHOOL
0	0	1,400	1,000	482	23,353	128,676	0	0	230	0	0	1,762,693	138,165	487	LA LOUISE S. MCGEHEE SCHOOL
0	0	875	875	381	36,782	128,768	0	0	266	13	12,395	1,276,069	1,397,522	306	KY LOUISVILLE COLLEGIATE SCHOOL
0	NA	2,796	2,796	982	73,286	362,629	0	NA	NA	64	9,725	3,775,018	1,913,740	1,463	GA LOVETT SCHOOL
4,383	0	1,300	1,400	239	12,099	302,210	NA	NA	NA	29	26,303	1,532,071	421,787	284	CT LOW-HEYWOOD THOMAS SCHOOL
64,330	0	11,931	9,990	2,262	325,364	1,067,364	0	0	0	28	14,443	5,436,423	3,317,570	1,093	IL LOYOLA ACADEMY
0	0	1,040	1,000	295	37,000	92,090	0	0	0	0	735	1,916,736	265,918	198	NY LOYOLA SCHOOL
5,000	0	3,734	3,601	1,985	380,310	331,301	0	0	NA	3	0	3,038,735	7,262,400	337	VA MADEIRA SCHOOL
0	0	2,907	1,984	636	37,681	110,836	2,210	0	58,862	31	7,085	1,446,441	17,200	448	PA MALVERN PREPARATORY SCHOOL
0	0	970	480	16	5,485	67,110	0	0	0	7	2,370	2,031,400	125,970	491	DC MARET SCHOOL
64,000	0	1,331	1,216	307	16,272	216,633	0	0	0	8	1,117	919,333	162,300	131	IN MARIAN HEIGHTS ACADEMY
0	0	699	699	68	1,230	121,004	0	0	0	6	2,473	NA	30,395	201	CA MARIN ACADEMY

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INDEPENDENT SECONDARY AND ELEMENTARY SCHOOLS (CONT.)

[illegible]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
MARINE MILITARY ACADEMY	1,158,876	325,901	160,000	344,623	0	341,672	0	652	11,639	787,069	271,662	179,877	991	9,106
MARLBOROUGH SCHOOL	916,094	233,063	156,391	0	10,906	186,144	0	130,121	109,637	80,056	105,375	2,305	0	0
MARYWOOD SCHOOL	106,839	71,318	5,207	80,060	0	973	0	56,742	53,115	81,067	11,500	6,615	0	0
MARY INSTITUTE	667,329	602,390	36,979	30,000	0	0	0	217,601	216,327	16,630	21,091	0	0	0
MARYMOUNT SCHOOL	300,356	162,101	0	61,173	0	0	0	25,738	78,333	38,973	6,000	6,090	21,190	36,188
MASTERS SCHOOL	1,346,273	693,171	36,113	308,230	376,730	38,000	0	1,104,600	128,697	20,097	38,665	30,232	0	21,322
MAUMEE VALLEY C. D. SCHOOL	334,838	183,000	0	220,400	30	3,300	0	166,275	66,916	61,639	65,000	19,000	0	0
MAYFIELD SENIOR SCHOOL	196,675	120,706	20,170	0	37,896	11,303	0	6,706	38,057	[illegible]	19,096	2,375	0	76,260
[illegible] SCHOOL	106,636	106,336	300	0	0	0	0	[illegible]	61,160	11,253	17,325	10,650	0	0
MCCALLIE SCHOOL	1,239,370	662,611	86,783	0	653,272	29,906	9,000	609,229	168,097	6,525	328,519	67,662	0	2,638
MCDONOGH SCHOOL	968,130	431,723	93,360	68,000	0	[illegible]	0	799,868	116,603	[illegible]	63,998	6,603	0	0
MEMPHIS UNIVERSITY SCHOOL	806,756	184,326	22,329	2,500	133,700	319,992	0	[illegible]	136,837	536,908	66,353	38,579	0	1,736
MENLO SCHOOL	998,270	915,266	110,018	62,369	2,661	0	0	23,091	1,761	63,622	38,057	7,637	262,310	0
MERCERSBURG ACADEMY	1,028,369	301,766	67,667	117,603	228,631	330,620	21,000	706,932	66,200	122,602	318,000	36,305	7,150	0
METAIRIE PARK C. D. SCHOOL	377,060	310,116	66,566	1,000	0	16,000	0	95,733	217,702	8,619	16,000	6,875	0	33,631
MIAMI VALLEY SCHOOL	130,300	68,130	13,399	52,763	0	23,000	0	2,000	66,293	28,255	25,000	8,363	0	23,369
MIDDLESEX SCHOOL	1,362,000	631,166	30,006	3	323,269	866,933	0	392,613	308,287	868	197,730	71,390	0	0
MILLBROOK SCHOOL	825,926	864,232	77,313	215,326	888,433	0	0	273,606	99,670	393,061	36,153	22,966	0	0
MILTON ACADEMY	2,129,316	1,001,918	636,371	137,327	12,395	373,363	65,736	1,095,970	275,068	376,978	262,075	161,223	0	0
MISS HALL'S SCHOOL	300,305	194,200	0	69,003	0	37,390	0	130,903	160,930	3,727	17,500	7,565	0	0
MISS PORTER'S SCHOOL	1,991,480	912,325	166,329	0	621,231	909,556	0	1,221,201	607,703	72,803	136,300	0	0	68,891
MISSOURI MILITARY ACADEMY	266,099	560	26,006	192,662	0	26,631	0	195,037	66,396	3,668	19,175	2,625	0	0
MMI PREPARATORY SCHOOL	103,979	28,705	25,125	22,979	0	26,770	0	12,071	26,503	25,565	27,500	11,000	0	0
MONTCLAIR KIMBERLEY ACAD.	307,632	257,606	100,235	10,000	27,063	2,050	0	76,376	[illegible]	97,219	68,300	16,200	0	26,671
MONTGOMERY BELL ACADEMY	1,312,606	13,022	2,000	219,231	1,077,733	0	0	11,630	[illegible]	1,286,566	6,011	875	0	0
MOORESTOWN FRIENDS SCHOOL	565,333	126,006	173,965	231,100	16,300	0	0	67,755	73,023	331,061	32,900	6,906	68,170	6,100
MORAVIAN ACADEMY	321,117	132,301	13,233	29,670	[illegible]	116,632	0	25,001	62,107	70,053	35,300	23,090	6,001	68,825
MORGAN PARK ACADEMY	127,830	101,650	0	0	[illegible]	0	0	7,857	62,011	66,621	0	10,901	0	0
MOUNT TAMALPAIS PRIMARY SCHOOL	166,790	93,298	0	1,300	0	56,000	0	0	133,998	7,525	1,000	2,275	0	0
MOUNTAIN SCHOOL	106,300	76,000	36,000	0	0	[illegible]	0	0	61,000	66,000	15,003	6,500	0	0
NASHOBA BROOKS SCH. OF CONCORD	308,960	72,778	190	236,012	0	0	0	2,037	167,638	135,111	0	6,366	0	0
NATIONAL CATHEDRAL SCHOOL	1,692,718	382,032	90,338	183,673	[illegible]	666,935	0	236,392	371,650	630,169	153,500	15,826	6,000	72,223
NEW CANAAN COUNTRY SCHOOL	539,601	209,736	69,637	125,770	131,996	2,303	0	195,067	168,687	86,702	19,500	10,369	0	69,657
NEW HAMPTON SCHOOL	606,308	166,839	0	66,373	0	35,096	290,000	396,600	26,686	63,068	27,000	6,366	0	0
NEW YORK MILITARY ACADEMY	31,022	7,570	10,001	0	13,231	0	0	22,600	6,500	1,260	0	600	0	0
NEWTON C.D. SCH. SACRED HEART	102,191	86,191	16,000	0	0	0	0	21,366	30,917	6,220	7,900	1,678	12,000	32,900
NICHOLS SCHOOL	377,363	862,312	29,000	6,000	72,535	8,990	0	167,979	152,910	53,168	20,058	8,030	0	0
NIGHTINGALE-BAMFORD SCHOOL	889,333	296,663	125,116	0	667,996	0	0	71,915	910,613	137,670	122,300	27,035	0	0
NOBLE AND GREENOUGH SCHOOL	888,092	330,175	62,019	337,886	66,006	73,218	0	192,063	122,323	12,730	107,309	35,342	0	618,203
NORFOLK ACADEMY	1,028,932	176,698	0	866,656	0	0	0	161,872	721,900	157,120	0	0	0	0
NORFOLK COLLEGIATE SCHOOL	95,312	83,312	12,000	0	0	0	0	300	60,206	15,000	0	150	0	31,578
NORMAN HOWARD SCHOOL	92,336	60,736	16,911	17,150	0	3,761	0	0	3,737	30,611	18,911	11,277	0	0
NORTH COUNTRY SCHOOL	200,121	135,899	25,677	16,950	21,065	5,730	0	[illegible]	72,386	36,026	31,000	7,729	0	0
NORTH SHORE C. D. SCHOOL	1,158,577	313,617	300	15,040	627,519	133,001	60,000	[illegible]	360,319	11,760	96,010	36,630	0	121,000
NORTHFIELD MOUNT HERMON SCHOOL	2,737,336	806,305	302,909	0	962,326	387,716	180,000	1,792,667	356,776	801,992	307,330	88,169	0	0
NORTHWESTERN MIL. & NAVAL ACAD.	137,037	65,279	19,736	60,622	0	12,600	0	76,676	23,096	10,355	1,075	650	0	27,505
NORTHWOOD SCHOOL	266,587	118,331	38,000	96,056	0	0	0	108,065	66,150	21,362	90,000	0	0	0
OAK GROVE-COBURN SCHOOL	66,057	63,557	2,500	0	0	0	0	9,672	2,000	8,128	2,500	300	170	23,279
OAK KNOLL SCH. OF HOLY CHILD	131,670	91,370	60,300	0	0	0	0	16,365	76,110	12,730	17,300	11,163	0	0
OLD TRAIL SCHOOL	203,000	196,000	8,000	0	0	39,000	0	36,729	36,657	20,875	100,500	0	0	36,127
OLD WESTBURY SCH. HOLY CHILD	63,636	63,636	0	0	0	0	0	1,633	36,633	1,325	0	3,030	0	1,193
OLDFIELDS SCHOOL	386,806	283,631	0	101,191	0	0	0	131,029	91,175	6,046	151,090	6,606	500	0
OLNEY FRIENDS SCHOOL	80,336	33,116	25,017	0	30	325	0	27,706	1,079	3,676	11,230	325	16,286	60
OREGON EPISCOPAL SCHOOL	366,797	103,220	82,036	36,832	1,032	22,077	0	65,630	35,066	86,360	69,322	6,129	0	25,302
OVERLAKE SCHOOL	183,322	95,022	58,300	0	29,000	0	0	1,712	67,608	09,652	19,636	6,020	0	0
PACKER COLLEGIATE INST.	366,293	173,678	67,003	0	36,336	112,996	0	263,170	60,155	16,320	23,500	10,290	0	16,850

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
34,096	NA	NA	NA	23	642	88,930	23,439	17,887	183,257	13	133,385	4,776,431	7,171,180	340	TX MARINE MILITARY ACADEMY
0	0	3,730	3,730	719	79,652	387,966	0	0	NA	0	0	2,638,271	6,030,235	408	CA MARLBOROUGH SCHOOL
0	0	470	438	73	8,737	71,318	0	0	0	13	6,415	1,066,881	2,116	130	CT MARVELWOOD SCHOOL
0	0	3,417	3,323	2,000	189,170	486,300	0	0	0	0	0	3,297,403	3,190,967	617	MO MARY INSTITUTE
300	0	1,400	1,100	144	6,172	143,101	NA	NA	NA	12	5,400	NA	NA	323	NY MARYMOUNT SCHOOL
36,000	0	4,636	4,343	1,437	312,872	380,063	0	0	NA	77	80,232	3,782,981	6,075,152	340	NY MASTERS SCHOOL
0	0	1,270	1,270	436	63,000	181,000	NA	NA	NA	0	0	1,335,000	1,157,000	472	OH MAUMEE VALLEY C. D. SCHOOL
0	0	1,317	1,317	30	3,786	149,876	2,346	0	11,876	0	2,375	1,280,741	1,461,036	212	CA MAYFIELD SENIOR SCHOOL
0	0	2,165	2,165	263	24,000	184,334	0	0	4,280	12	10,525	NA	0	272	NY MCBURNEY SCHOOL
0	28,332	3,483	3,108	1,700	279,267	482,411	0	0	325	16	8,407	4,330,308	6,927,570	482	TN MCCALLIE SCHOOL
0	0	4,300	3,700	1,183	110,196	323,000	0	0	35,081	0	0	5,063,838	9,382,368	1,133	MD MCDONOGH SCHOOL
0	0	1,696	1,696	580	31,237	144,356	0	0	1,381	12	1,536	1,621,275	1,990,283	373	TN MEMPHIS UNIVERSITY SCHOOL
0	0	2,190	2,190	60	4,600	230,812	0	0	0	3	4,000	678,011	59,405	220	CA MENLO SCHOOL
NA	0	9,363	9,363	3,386	617,464	369,393	0	0	4,235	113	29,895	3,890,475	9,190,206	387	PA MERCERSBURG ACADEMY
0	0	1,783	1,457	383	89,121	327,161	1,180	0	34,300	10	2,175	3,342,176	1,388,634	721	LA METAIRIE PARK C. D. SCHOOL
0	0	323	323	84	2,000	46,301	0	0	12,200	7	1,723	1,291,367	194,623	362	OH MIAMI VALLEY SCHOOL
0	0	2,360	2,231	1,384	361,369	631,164	0	0	795	0	0	3,164,312	13,082,092	290	MA MIDDLESEX SCHOOL
0	0	1,331	1,302	700	110,065	264,232	2,300	0	10,000	32	10,700	1,662,836	2,340,000	183	NY MILLBROOK SCHOOL
14,942	0	3,083	3,280	2,382	420,081	916,287	0	0	0	139	33,133	9,224,341	30,790,837	905	MA MILTON ACADEMY
0	0	2,710	2,000	300	110,099	194,300	0	0	1,900	24	5,045	NA	133,095	207	MA MISS HALL'S SCHOOL
69,087	45,190	4,387	4,244	2,140	481,145	668,036	0	0	325	121	41,093	4,138,732	13,323,601	305	CT MISS PORTER'S SCHOOL
119,166	0	2,969	2,969	180	36,400	127,733	435	0	17,979	3	790	NA	NA	320	MO MISSOURI MILITARY ACADEMY
0	0	1,230	1,230	196	7,750	36,705	0	0	0	0	0	NA	720,302	326	PA MMI PREPARATORY SCHOOL
2,130	0	4,066	4,066	986	72,356	303,063	0	0	0	33	15,280	4,780,048	3,017,465	1,043	NJ MONTCLAIR KIMBERLEY ACAD.
0	0	2,300	1,300	70	11,636	63,437	0	10,000	0	NA	875	1,403,131	3,118,990	675	TN MONTGOMERY BELL ACADEMY
14,302	0	2,073	2,073	835	33,903	126,000	0	0	0	32	6,906	2,263,106	1,739,000	606	NJ MOORESTOWN FRIENDS SCHOOL
2,300	0	2,233	2,229	535	43,882	143,424	2,300	0	0	31	3,890	2,342,900	953,600	378	PA MORAVIAN ACADEMY
0	0	1,310	1,310	91	7,837	101,830	0	0	0	3	3,835	2,120,567	187,400	446	IL MORGAN PARK ACADEMY
0	0	37	10	0	0	93,298	300	0	0	4	2,275	NA	73,000	148	CA MOUNT TAMALPAIS PRIMARY SCHOOL
0	0	NA	0	0	0	0	0	0	0	0	0	NA	100,000	48	VT MOUNTAIN SCHOOL
131,981	0	890	830	65	2,916	72,920	0	0	296	7	4,366	NA	32,673	236	MA NASHOBA BROOKS SCH. OF CONCORD
344,036	0	3,380	3,130	757	64,706	226,312	0	0	0	37	15,636	3,763,299	4,421,695	318	DC NATIONAL CATHEDRAL SCHOOL
37,687	0	1,763	1,010	361	41,963	209,736	0	0	0	33	10,369	3,300,000	2,636,000	487	CT NEW CANAAN COUNTRY SCHOOL
0	0	3,780	3,700	600	81,617	144,839	0	18,140	0	0	0	2,058,133	772,298	327	NH NEW HAMPTON SCHOOL
0	0	3,064	3,064	177	22,602	31,022	0	0	0	3	905	2,336,000	334,000	344	NY NEW YORK MILITARY ACADEMY
0	0	1,300	1,300	311	13,364	51,031	0	0	0	21	1,630	1,200,000	318,232	225	MA NEWTON C.D. SCH. SACRED HEART
4,000	NA	3,000	2,930	1,169	137,161	259,082	0	0	0	1	2,830	4,334,630	1,714,276	667	NY NICHOLS SCHOOL
3	0	1,338	1,800	300	26,501	290,463	0	0	0	0	0	3,251,977	3,105,233	472	NY NIGHTINGALE-BAMFORD SCHOOL
1,000	3,900	2,341	2,002	1,405	104,231	330,173	3,000	0	68,230	56	28,666	3,304,923	6,194,271	427	MA NOBLE AND GREENOUGH SCHOOL
23,000	NA	2,190	2,032	913	33,495	176,690	0	0	48,035	NA	NA	3,774,211	3,267,036	1,066	VA NORFOLK ACADEMY
0	0	800	713	16	300	95,312	0	0	0	1	30	1,408,907	50,000	700	VA NORFOLK COLLEGIATE SCHOOL
0	0	3	0	0	0	68,132	300	0	8,430	3	675	467,092	68,849	38	NY NORMAN HOWARD SCHOOL
0	0	1,033	835	191	20,944	135,535	NA	NA	NA	17	6,236	1,223,980	34,341,037	80	NY NORTH COUNTRY SCHOOL
0	0	NA	0	0	0	0	NA	NA	NA	31	18,448	2,535,971	1,257,275	481	IL NORTH SHORE C. D. SCHOOL
837,761	85,733	21,845	21,705	3,052	650,400	956,390	0	0	0	300	79,449	14,872,441	30,891,747	1,140	MA NORTHFIELD MOUNT HERMON SCHOOL
0	0	1,130	1,073	453	47,304	66,343	0	0	15,606	7	636	1,430,310	75,360	172	WI NORTHWESTERN MIL.& NAVAL ACAD.
0	0	1,300	1,100	235	93,795	168,331	0	0	0	9	1,160	1,193,616	10,000	130	NY NORTHWOOD SCHOOL
3,000	0	NA	NA	96	9,672	37,159	0	0	0	0	0	NA	0	116	ME OAK GROVE-COBURN SCHOOL
0	0	1,062	1,062	127	16,385	131,678	0	0	0	30	11,163	1,029,633	636,200	442	NJ OAK KNOLL SCH. OF HOLY CHILD
0	0	850	750	270	34,729	304,858	0	0	4,500	9	1,975	NA	1,422,000	297	OH OLD TRAIL SCHOOL
0	0	331	400	22	1,625	63,629	0	0	0	7	3,030	1,324,323	1,928,197	330	NY OLD WESTBURY SCH. HOLY CHILD
0	0	1,390	1,402	356	90,323	168,967	0	0	0	0	1,836	1,901,321	654,700	183	MD OLDFIELDS SCHOOL
0	0	1,360	1,214	280	27,786	63,156	125	81	730	3	330	324,763	855,090	63	OH OLNEY FRIENDS SCHOOL
8,013	NA	1,010	1,010	264	24,630	186,336	1,000	0	0	0	0	NA	772,000	313	OR OREGON EPISCOPAL SCHOOL
0	0	300	330	30	1,712	95,852	0	0	0	3	720	1,490,000	70,000	231	WA OVERLAKE SCHOOL
167,330	0	3,099	4,357	1,279	98,265	173,678	0	0	NA	37	18,290	3,947,520	3,244,400	688	NY PACKER COLLEGIATE INST.

INDEPENDENT SECONDARY AND ELEMENTARY SCHOOLS (CONT.)

[illegible]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PALMER SCHOOL	46,881	46,881	0	0	0	0	0	250	27,790	16,841	1,000	1,000	0	0
PARK SCHOOL	652,936	165,974	31,721	195,305	21,000	263,734	0	64,795	159,626	158,464	239,985	15,000	0	23,264
PARK SCHOOL	189,305	160,003	0	13,948	0	35,354	0	3,895	111,675	69,190	3,000	2,025	0	0
PARK SCHOOL OF BUFFALO	254,286	204,870	49,416	0	0	0	0	56,589	60,253	56,389	46,619	6,080	0	32,356
PARK-TUDOR SCHOOL	177,619	95,455	49,024	17,884	0	15,250	0	38,226	63,165	17,765	11,000	7,398	0	40,107
PATTERSON SCHOOL	165,362	69,360	41,000	0	0	75,000	0	6,370	8,660	27,302	100,000	5,890	15,030	0
PEDDIE SCHOOL	1,801,321	335,962	230,550	65,335	1,066,920	153,560	0	1,590,625	93,696	63,287	100,000	29,215	0	24,700
PEMBROKE C.D. SCHOOL	372,718	248,356	48,605	31,076	15,395	36,600	0	103,263	90,332	68,759	20,013	26,126	0	6,225
PENNINGTON SCHOOL	193,191	78,423	0	37,076	76,022	3,670	0	26,895	58,135	33,206	0	81,066	3,585	506
PERKINS SCHOOL FOR THE BLIND	591,000	591,000	0	0	0	0	0	0	0	476,955	76,565	61,500	0	0
PERKIOMEN SCHOOL	269,273	86,766	72,768	50,632	290	60,836	0	133,721	57,698	38,462	26,000	6,068	7,349	0
PHILLIPS ACADEMY	4,956,755	1,601,530	308,691	137,620	202,138	2,316,206	112,500	2,786,782	621,335	306,165	986,326	256,100	0	0
PHILLIPS EXETER ACADEMY	4,612,026	[illegible]	1,670,792	262,915	673,672	1,068,666	100,000	3,194,579	468,687	75,200	631,228	238,332	0	0
PHOENIX COUNTRY DAY SCHOOL	309,392	185,085	39,690	106,280	5,725	12,672	0	2,568	209,661	1,629	60,500	2,986	0	12,368
PIKE SCHOOL	330,696	119,188	250	108,066	68,000	0	0	2,795	250,566	31,103	2,000	6,230	0	68,000
PILOT SCHOOL	313,264	68,357	70,177	155,000	27,730	0	0	880	57,696	71,906	182,790	0	0	0
PINE CREST SCHOOL	1,228,989	689,000	43,930	462,036	176,066	116,381	2,000	15,787	435,085	652,617	102,500	2,000	0	0
PINGREE SCHOOL	221,295	99,536	0	10,000	0	111,759	0	13,191	35,699	81,785	60,200	10,700	0	0
PINGRY SCHOOL	1,956,687	295,673	213,699	1,447,315	0	0	0	803,896	296,969	219,355	626,967	11,000	0	0
POLYTECHNIC PREP. C. D. SCH.	293,236	178,193	250	60,767	0	54,066	0	110,073	111,906	15,317	27,500	22,438	0	0
POLYTECHNIC SCHOOL	1,925,000	373,059	172,221	923,859	450,620	11,661	0	249,963	220,386	535,269	822,663	96,995	0	0
POMFRET SCHOOL	683,509	238,716	70,636	121,626	136,771	96,232	0	308,572	169,596	67,000	118,333	19,290	0	0
PORTLEDGE SCHOOL	401,196	263,220	11,221	126,753	0	0	0	695	96,782	139,866	162,300	1,553	0	0
POTOMAC SCHOOL	423,636	296,377	38,000	25,000	5,000	64,259	0	50,968	107,207	138,931	90,000	1,450	0	0
POWHATAN SCHOOL	50,678	43,882	6,796	0	0	0	0	5,922	7,206	13,797	0	0	0	23,755
PRAIRIE SCHOOL	236,272	223,083	12,612	500	0	275	0	27,565	26,358	131,076	0	51,273	0	0
PRINCETON DAY SCHOOL	278,592	198,536	67,647	0	6,302	26,031	0	27,121	107,692	130,969	0	12,839	0	0
PROFESSIONAL CHILDREN'S SCHOOL	232,998	30,383	132,290	28,900	0	41,225	0	6,626	8,895	33,367	109,203	76,852	0	0
PROVIDENCE COUNTRY DAY SCHOOL	282,466	75,955	0	106,311	0	0	0	69,637	61,768	39,616	102,211	9,237	0	1,017
PUNAHOU SCHOOL	2,019,096	1,082,739	250,326	797,303	18,133	73,601	0	1,302,366	436,690	374,876	243,666	203,272	0	2,726
PURNELL SCHOOL	620,376	119,000	0	205,303	56,995	241,381	0	23,623	488,525	5,662	89,625	13,161	0	0
PUTNEY SCHOOL	269,503	171,681	56,606	23,500	20,000	0	0	93,463	133,202	46,180	0	0	0	0
RANSOM-EVERGLADES SCHOOL	218,963	184,723	13,595	0	650	15,175	0	35,359	136,652	38,689	5,232	5,275	0	200
RECTORY SCHOOL	225,788	189,361	77,339	20,788	0	4,600	0	19,376	159,201	17,170	19,053	5,310	0	0
REGIS HIGH SCHOOL	1,503,616	711,930	0	20,000	593,599	176,087	0	1,146,266	27,463	87,622	161,100	68,609	0	33,270
RIVERDALE COUNTRY SCHOOL	697,039	338,675	65,250	22,000	183,463	169,883	0	69,571	216,408	396,330	0	6,250	0	8,500
ROBERT LOUIS STEVENSON SCHOOL	386,853	174,126	65,502	106,033	0	41,367	0	39,016	75,803	143,171	127,903	6,960	0	0
ROCKY HILL SCHOOL	206,369	62,177	17,000	125,072	0	0	0	5,063	68,196	57,673	51,603	61,930	0	0
ROXBURY LATIN SCHOOL	823,096	233,977	21,037	71,197	227,381	256,506	13,000	325,271	106,120	151,730	186,350	52,611	0	0
RUMSEY COUNTRY DAY SCHOOL	167,826	83,726	6,000	28,300	26,500	5,300	0	3,232	74,211	13,900	53,000	3,425	0	0
RUTGERS PREPARATORY SCHOOL	208,966	56,888	33,000	121,578	200	2,500	0	31,902	111,816	22,829	31,253	6,570	0	6,511
SACRED HEART SCHOOLS	838,913	19,005	165,977	672,156	0	1,575	0	73,303	453,129	53,360	80,200	60,127	552	118,275
SACRED HEART SCHS.-SHERIDAN RD.	257,466	204,396	32,092	20,168	0	0	0	22,139	23,562	96,986	26,000	860	16,301	75,660
SADDLE RIVER DAY SCHOOL	201,905	192,005	5,066	1,834	2,220	0	0	2,306	113,636	1,555	6,300	37,859	0	40,568
ST. AGNES SCHOOL	213,713	90,390	38,175	62,993	16,653	600	0	26,177	71,799	22,116	63,253	17,170	1,300	31,200
ST. ANDREW'S EPISCOPAL SCHOOL	92,369	66,109	26,160	0	0	0	0	100	72,168	11,161	6,250	2,700	150	0
ST. ANDREW'S ON THE MARSH	42,409	0	9,875	32,534	0	0	0	0	5,236	14,671	6,500	17,003	0	0
ST. ANDREW'S SCHOOL	386,962	118,903	15,268	252,796	0	0	0	83,613	78,969	66,593	140,000	7,287	0	5,000
ST. ANDREW'S SCHOOL	553,769	221,102	40,203	233,666	0	55,777	0	6,220	121,697	416,365	7,755	325	700	0
ST. ANDREW'S-SEWANEE SCHOOL	221,412	181,375	0	0	26,287	11,753	0	69,315	22,360	127,737	16,925	2,300	3,195	0
ST. ANN'S SCHOOL	82,463	45,616	21,560	12,502	0	0	0	413	36,503	16,206	1,060	5,700	0	24,646
ST. ANSELM'S ABBEY SCHOOL	127,471	101,221	26,250	0	0	0	0	31,267	53,494	33,665	11,300	3,390	0	650
ST. CHRISTOPHER'S SCHOOL	838,625	400,367	0	166,565	36,076	236,634	0	377,505	148,856	141,401	122,836	41,261	0	6,268
ST. DOMINIC ACADEMY	52,495	23,215	0	0	0	29,483	0	46,796	3,460	0	0	295	0	0
ST. FRANCIS HIGH SCHOOL	46,286	46,286	0	0	0	0	0	177	17,856	33,255	0	0	0	0
ST. GENEVIEVE/GIBBONS HALL SCH.	132,517	67,562	0	64,597	360	0	0	676	131,166	600	0	75	0	0

0	0	434	434	1	250	46,881	0	0	3,491	2	638	00	0	333	PL PALMER SCHOOL
235,000	235,000	2,126	2,007	646	20,009	171,119	3,225	700	28,178	0	1,338	2,026,745	1,461,460	619	PA PARK SCHOOL
0	3	3,300	2,880	90	3,093	137,733	0	0	0	6	2,023	2,077,235	510,282	403	MA PARK SCHOOL
1,383	0	1,330	1,400	490	34,309	254,206	0	0	0	10	3,700	2,000,000	125,000	362	NY PARK SCHOOL OF BUFFALO
0	0	3,075	3,075	367	27,401	95,651	0	0	0	28	5,100	3,199,221	13,434,990	700	IN PARK-TUDOR SCHOOL
0	0	525	525	40	6,329	53,962	0	0	18,000	0	0	537,510	300,000	131	NC PATTERSON SCHOOL
7,750	0	6,122	6,122	1,821	143,233	348,795	0	0	246,000	77	14,215	00	1,941,970	511	NJ PEDDIE SCHOOL
356	0	2,916	2,916	1,280	130,358	309,351	0	0	0	36	14,875	2,436,229	2,300,000	510	MD PEMBROKE C.D. SCHOOL
3,039	0	2,093	2,093	237	18,312	78,423	1,136	500	11,406	16	2,305	2,567,219	2,300,000	321	NJ PENNINGTON SCHOOL
1,527,943	0	00	00	00	0	380,442	0	0	0	88	1,013	10,701,098	39,404,000	219	MA PERKINS SCHOOL FOR THE BLIND
51,752	6,000	3,190	3,190	900	64,900	157,318	0	0	17,411	10	3,675	1,918,403	711,018	225	PA PERKIOMEN SCHOOL
231,822	00	19,362	10,320	7,840	1,378,960	1,801,330	0	0	15,606	632	100,753	17,792,254	92,267,491	1,209	MA PHILLIPS ACADEMY
350,003	22,331	17,096	15,349	7,956	1,397,164	1,618,925	0	0	0	339	100,034	13,027,909	84,721,403	965	NH PHILLIPS EXETER ACADEMY
0	0	444	412	19	1,383	132,347	0	500	2,350	3	2,900	2,641,900	1,316,446	363	AZ PHOENIX COUNTRY DAY SCHOOL
30,000	0	1,044	978	63	2,795	119,180	0	0	6,312	6	4,230	1,363,013	256,720	392	PA PIKE SCHOOL
0	0	0	0	0	0	0	0	0	0	0	0	00	1,100,019	163	DE PILOT SCHOOL
0	0	3,100	3,100	606	11,295	400,000	0	0	0	0	0	8,399,273	1,773,075	1,376	FL PINE CREST SCHOOL
0	0	924	826	252	11,861	90,537	1,000	0	0	22	10,700	1,464,900	550,000	232	MA PINGREE SCHOOL
3	0	6,601	3,151	1,030	143,000	293,673	0	0	0	111	30,190	6,250,000	1,141,000	935	NJ PINGRY SCHOOL
10,900	0	3,500	3,500	853	78,134	178,643	800	9,000	1,179	56	21,700	3,844,200	2,250,004	636	NY POLYTECHNIC PREP. C. D. SCH.
434,875	0	00	0	0	0	0	0	0	0	25	24,635	3,794,866	5,169,100	768	CA POLYTECHNIC SCHOOL
1,000	0	2,678	2,400	990	140,632	329,172	0	0	00	51	11,863	3,717,262	5,279,306	350	CT POMFRET SCHOOL
34,000	0	262	262	25	695	274,461	0	0	0	3	1,333	1,573,687	0	285	NY PORTLEDGE SCHOOL
3,000	0	1,030	1,030	850	67,900	324,767	0	0	3,000	0	1,430	00	864,309	539	VA POTOMAC SCHOOL
0	0	330	330	34	626	38,177	0	0	4,000	1	50	00	0	129	VA POWHATAN SCHOOL
0	0	442	431	76	27,305	237,772	61,000	0	0	31	27,025	2,400,300	0	453	WI PRAIRIE SCHOOL
3	0	3,050	3,000	499	27,871	198,534	0	0	0	41	12,300	4,185,346	3,734,187	868	NJ PRINCETON DAY SCHOOL
0	0	1,250	1,200	134	4,686	162,873	0	0	0	7	1,325	1,327,399	394,589	215	NY PROFESSIONAL CHILDREN'S SCHOOL
0	0	1,000	1,000	227	18,183	75,955	0	0	0	4	3,032	1,434,341	350,000	316	RI PROVIDENCE COUNTRY DAY SCHOOL
271,801	00	17,982	15,626	4,220	366,330	813,040	0	0	0	224	55,670	14,000,000	16,500,000	3,780	HI PUNAHOU SCHOOL
0	6,300	00	0	0	0	3	0	0	0	20	8,161	1,400,863	804,643	129	NJ PURNELL SCHOOL
23,000	23,000	00	0	0	0	0	0	0	5,300	0	0	1,320,000	927,870	193	VT PUTNEY SCHOOL
3,003	3,000	2,031	2,031	373	35,339	380,763	0	0	19,042	7	4,675	3,035,925	1,944,042	623	FL RANSOM-EVERGLADES SCHOOL
0	0	2,007	1,683	252	17,685	186,000	9,132	6,586	15,718	21	3,310	00	1,254,199	177	CT RECTORY SCHOOL
324,379	0	3,444	3,444	3,390	421,098	711,930	0	0	3,000	84	68,449	2,919,068	18,726,648	500	NY REGIS HIGH SCHOOL
0	0	3,000	3,000	577	69,571	383,951	0	0	3,000	36	6,290	6,205,530	2,994,173	976	NY RIVERDALE COUNTRY SCHOOL
3	0	1,773	1,773	10	2,325	174,120	8,700	0	0	3	3,310	3,400,000	[illegible]	507	CA ROBERT LOUIS STEVENSON SCHOOL
0	0	692	692	91	2,903	62,177	0	2,900	0	10	2,225	1,394,356	134,146	271	RI ROCKY HILL SCHOOL
34,176	44,300	2,309	1,976	800	113,328	233,977	0	0	0	81	32,011	1,409,349	10,500,000	263	MA ROXBURY LATIN SCHOOL
0	0	900	900	73	3,230	83,726	0	0	0	12	2,925	1,018,000	374,236	365	NJ RUMSON COUNTRY DAY SCHOOL
12,795	0	2,389	2,300	900	6,305	84,088	00	00	00	22	4,875	2,779,131	303,632	530	NJ RUTGERS PREPARATORY SCHOOL
2,586	0	2,103	0	63	4,217	22,103	51,200	1,000	800	0	8,966	2,213,463	483,848	564	CA SACRED HEART SCHOOLS
74,913	0	2,000	1,770	300	32,366	103,478	0	0	0	6	800	1,733,858	467,311	323	IL SACRED HEART SCHS.-SHERIDAN R
0	0	444	397	86	2,309	197,831	0	0	0	8	1,030	1,813,307	[illegible]	375	NJ SADDLE RIVER DAY SCHOOL
0	0	1,483	1,370	411	24,177	110,090	0	00	00	14	615	1,994,275	332,767	554	VA ST. ANNES SCHOOL
0	0	30	30	0	950	64,109	300	2,000	9,000	0	0	00	0	323	MD ST. ANDREW'S EPISCOPAL SCHOOL
0	0	00	0	0	0	32,534	0	0	0	1	800	777,538	0	333	GA ST. ANDREW'S ON THE MARSH
5,000	0	2,297	1,915	782	88,169	132,166	0	0	00	61	7,287	3,723,[illegible]	28,778,746	267	DE ST. ANDREW'S SCHOOL
33,194	0	1,173	1,173	100	6,226	954,[illegible]	0	0	1,320	7	321	2,804,678	483,096	430	FL ST. ANDREW'S SCHOOL
31,207	0	6,000	6,000	160	49,315	101,371	0	3	10,000	86	500	497,068	1,789,300	283	TN ST. ANDREW'S-SEWANEE SCHOOL
0	0	448	438	36	610	89,963	0	0	3,048	16	3,700	[illegible]	90,000	766	NY ST. ANN'S SCHOOL
3	0	1,060	924	363	31,207	113,421	0	0	13,690	12	2,700	1,009,674	33,215	206	DC ST. ANSELM'S ABBEY SCHOOL
13,000	0	3,830	2,820	1,018	210,093	400,067	0	0	0	110	22,130	3,306,608	2,330,033	875	VA ST. CHRISTOPHER'S SCHOOL
0	0	2,700	2,700	820	10,316	23,013	0	0	0	0	0	911,955	332,034	530	NJ ST. DOMINIC ACADEMY
0	0	130	134	21	177	44,308	0	0	0	0	0	00	88,033	130	KY ST. FRANCIS HIGH SCHOOL
0	0	1,200	0	0	0	0	0	0	0	0	0	00	15,670	229	NC ST. GENEVIEVE/GIBBONS HALL SCH.

INDEPENDENT SECONDARY AND ELEMENTARY SCHOOLS (CONT.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
ST. GREGORY'S SCHOOL	60,070	60,070	0	0	3,000	0	0	2,365	34,065	6,960	1,500	2,200	0	0
ST. IGNATIUS HIGH SCHOOL	906,633	390,010	0	513,017	56,206	0	0	612,976	97,663	60,836	10,760	6,378	0	0
ST. JOHN'S MILITARY ACADEMY	758,703	621,999	96,909	123,547	0	16,650	0	295,371	177,565	96,956	184,000	6,095	0	0
ST. JOHN'S PARISH SCHOOL	13,137	6,000	7,137	0	0	0	0	155	5,660	2,605	0	0	1,000	6,157
ST. JOHN'S PREP. SCHOOL	669,729	376,696	96,196	59,093	0	137,566	0	86,569	21,120	91,560	57,500	11,650	377,337	26,213
ST. JOHN'S SCHOOL	2,408,062	500,790	0	911,100	969,371	218,013	0	873,500	540,003	609,169	805,600	60,896	0	0
ST. JOHNS COUNTRY DAY SCHOOL	61,064	0	1,063	60,001	0	0	0	1,550	36,176	16,930	6,750	660	0	5,216
ST. JOHNSBURY ACADEMY	186,695	98,023	10,033	77,676	10,006	555	0	110,066	13,715	16,791	30,000	9,165	0	0
ST. JOSEPH'S COLLEGIATE INST.	169,638	71,053	68,905	36,900	0	0	0	66,073	32,280	38,631	10,000	6,662	0	0
ST. LOUIS COUNTRY DAY SCHOOL	608,176	331,060	36,750	167,018	65,000	97,063	0	257,300	295,391	98,295	26,000	5,000	0	0
ST. LOUIS PRIORY SCHOOL	683,060	230,991	3,700	218,623	218,736	0	0	61,922	115,695	386,206	2,575	1,030	0	117,736
ST. MARGARET'S SCHOOL	818,106	121,621	0	60,710	627,975	0	0	61,703	61,039	218,907	306,326	22,951	500	0
ST. MARGARET'S-MCTERNAN SCHOOL	366,731	107,063	0	36,000	180,609	0	0	130,015	92,996	31,008	61,000	21,260	0	0
ST. MARK'S SCHOOL	1,001,006	302,197	16,301	[illegible]	10,671	311,092	28,300	1,002,637	206,662	66,919	151,003	33,763	0	0
ST. MARK'S SCHOOL OF TEXAS	1,670,136	603,703	73,730	170,000	16,795	310,030	9,000	292,058	660,638	26,581	609,260	28,199	0	1,600
ST. MARY'S HALL	368,327	203,165	87,668	91,073	0	83,607	0	101,232	189,601	138,109	36,030	5,575	100	0
ST. MICHAEL'S COUNTRY DAY SCH.	33,010	30,696	2,326	0	0	0	0	260	12,061	12,626	2,265	5,260	0	0
ST. PAUL ACAD. & SUMMIT SCH.	1,301,302	311,901	73,193	377,577	380,021	38,610	0	1,078,813	327,066	175,637	166,316	19,603	0	36,011
ST. PAUL'S SCHOOL	616,921	161,229	30,366	116,192	65,387	85,869	0	61,000	163,632	63,702	92,900	36,123	30	19,556
ST. PAUL'S SCHOOL	6,368,128	873,097	366,220	708,909	1,082,079	1,350,163	0	1,820,799	1,020,036	168,271	286,073	166,711	0	609,030
ST. PAUL'S SCHOOL FOR GIRLS	492,099	61,987	6,837	365,619	[illegible]	80,327	0	73,737	66,083	258,982	112,739	2,567	0	0
ST. SEBASTIAN'S C. D. SCHOOL	129,762	93,726	32,026	6,010	0	0	0	60,338	68,109	32,330	1,000	7,965	0	0
ST. STEPHEN'S EPISCOPAL SCH.	397,953	172,633	88,230	201,220	31,621	66,223	0	31,006	132,062	83,066	272,977	36,653	1,000	1,029
ST. STEPHEN'S SCHOOL	906,623	187,982	46,330	2,710	561,039	129,662	0	60,688	760,575	22,783	66,600	17,975	0	0
ST. THOMAS ACADEMY	633,673	237,087	68,370	62,626	237,300	53,110	0	169,253	65,273	276,561	1,200	39,020	0	106,566
ST. TIMOTHY'S SCHOOL	1,679,020	263,606	32,303	102,360	[illegible]	313,722	33,195	665,153	98,609	86,393	812,300	15,005	0	0
SALEM ACADEMY	185,221	76,903	30,360	30,101	915	69,853	0	66,967	68,751	63,660	3,750	36,163	550	0
SAN FRANCISCO DAY SCHOOL	363,015	163,703	79,367	120,065	0	0	0	0	166,952	113,773	77,630	6,030	0	0
SAN FRANCISCO UNIV. H.S.	813,160	119,018	236,001	372,731	58,290	16,000	11,003	1,662	268,221	305,632	118,690	18,733	0	139,200
SANTA CATALINA SCHOOL	886,651	363,370	56,991	259,007	[illegible]	65,603	0	133,996	162,839	362,069	165,915	6,075	0	77,139
SAVANNAH C. D. SCHOOL	630,782	139,100	16,670	236,682	0	51,330	0	63,896	171,366	87,160	50,000	107,300	0	0
SAYRE SCHOOL	251,303	112,750	6,730	59,016	33,600	16,779	0	38,620	110,175	18,790	12,000	18,935	0	36,703
SCRANTON PREPARATORY SCHOOL	321,963	18,013	25,000	216,712	0	72,236	0	206,136	116,779	50	0	1,000	0	0
SEABURY HALL	93,332	66,262	7,000	0	0	0	0	2,125	5,610	65,597	0	[illegible]	0	0
SERVITE HIGH SCHOOL	318,952	66,323	5,300	268,929	0	0	0	1,966	258,226	0	0	23,750	0	35,000
SEVEN HILLS SCHOOLS	895,852	301,088	60,100	0	180,601	666,063	0	612,088	127,120	72,336	62,915	[illegible]	0	39,600
SEVERN SCHOOL	276,296	32,237	16,352	230,337	0	1,330	0	56,060	83,960	83,605	66,200	5,135	0	7,016
SEWICKLEY ACADEMY	276,676	171,126	78,063	28,307	3,000	0	0	86,963	69,616	67,303	77,390	13,200	0	0
SHADY SIDE ACADEMY	780,707	303,387	78,307	57,729	167,980	30,976	0	176,701	163,202	162,606	136,386	60,070	0	23,300
SHERIDAN SCHOOL	196,639	96,776	57,363	0	0	42,300	0	2,756	99,001	795	60,200	790	0	30,200
SHIPLEY SCHOOL	1,317,636	365,569	79,565	606,095	73,673	396,736	15,600	320,538	306,629	206,503	317,356	21,078	0	139,656
SHORE COUNTRY DAY SCHOOL	161,058	[illegible]	0	0	0	39,112	0	16,611	103,003	36,667	[illegible]	5,095	0	0
SHORECREST PREPARATORY SCHOOL	198,332	113,306	20,236	68,992	0	0	0	970	100,223	65,673	0	23,886	0	0
SIDWELL FRIENDS SCHOOL	1,695,682	691,176	332,682	371,088	65,671	175,987	59,000	118,990	697,360	232,617	205,285	5,975	0	236,987
SOLEBURY SCHOOL	89,326	32,351	7,695	0	23,729	25,769	0	56,201	5,033	19,660	1,100	650	0	7,100
SOUTH KENT SCHOOL	392,626	278,627	38,386	11,500	266,053	200	7,000	302,958	202,828	38,125	31,203	17,531	0	0
SPARTANBURG DAY SCHOOL	287,857	207,009	66,368	36,500	0	0	0	1,965	36,686	61,175	175,206	19,950	0	15,097
SPENCE SCHOOL	760,216	391,679	28,002	0	277,903	51,750	0	75,062	399,170	55,677	5,003	23,327	0	192,578
STANSTEAD COLLEGE	176,366	25,191	10,953	0	113,605	27,000	0	17,615	6,516	5,560	165,600	675	0	0
STATEN ISLAND ACADEMY	515,271	216,509	21,000	0	277,762	0	0	153,655	120,906	32,232	36,003	0	0	155,678
STONELEIGH-BURNHAM SCHOOL	297,905	89,916	36,325	173,662	0	0	0	73,177	169,060	29,575	16,006	9,313	0	0
STONY BROOK SCHOOL	1,030,667	686,006	0	366,663	0	0	0	256,317	362,012	236,085	212,560	6,669	6,000	16,996
STUART COUNTRY DAY SCH. -S.H.	256,363	76,676	7,096	6,150	166,906	16,733	0	6,036	67,760	83,813	76,273	17,007	0	21,076
STUART HALL	232,767	96,899	0	0	0	137,060	0	25,375	16,136	127,296	61,625	2,535	0	0
STUDY	63,662	0	0	32,007	0	11,355	0	5,165	27,667	2,600	8,253	0	0	0
SUFFIELD ACADEMY	695,253	175,000	[illegible]	32,916	220,000	31,336	13,000	123,766	210,597	61,707	96,303	25,960	100	1,600

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0	0	390	950	40	2,303	31,670	0	0	0	2	1,190	356,393	25,000	381	NY ST. GREGORY'S SCHOOL
0	0	11,591	6,387	2,400	364,953	422,383	0	0	0	123	23,743	1,999,788	1,752,691	1,338	OH ST. IGNATIUS HIGH SCHOOL
0	0	3,235	3,235	281	394,487	705,673	300	13,006	13,021	6	2,000	2,714,423	244,479	374	WI ST. JOHN'S MILITARY ACADEMY
0	0	176	176	0	153	1,900	0	0	0	0	0	292,986	0	130	MD ST. JOHN'S PARISH SCHOOL
0	0	2,871	2,871	481	32,970	473,493	13,373	0	0	23	4,315	1,097,988	737,984	290	MN ST. JOHN'S PREP. SCHOOL
0	0	1,884	1,758	740	908,436	303,790	0	0	NA	48	29,396	3,862,273	7,723,500	1,094	TX ST. JOHN'S SCHOOL
0	0	340	325	17	1,330	40,000	2,093	0	0	2	440	1,809,160	128,323	549	FL ST. JOHNS COUNTRY DAY SCHOOL
0	18,000	7,975	7,901	2,391	78,894	94,210	0	0	0	0	0	2,058,033	4,752,704	647	VT ST. JOHNSBURY ACADEMY
0	0	3,484	3,484	980	31,088	71,953	0	0	0	31	4,442	1,703,425	701,701	845	NY ST. JOSEPH'S COLLEGIATE INST.
38,000	0	2,495	2,330	1,213	179,738	333,040	0	0	0	30	3,300	2,743,845	3,000,000	495	MO ST. LOUIS COUNTRY DAY SCHOOL
71,790	0	847	796	399	31,003	394,891	0	0	16,918	14	1,830	1,344,387	4,033,044	323	MO ST. LOUIS PRIORY SCHOOL
3,000	0	2,088	1,483	775	14,307	121,421	1,500	0	8,000	6	440	1,127,487	1,111,744	138	VA ST. MARGARET'S SCHOOL
0	0	2,448	2,440	473	[illegible]	107,043	0	NA	444	31	7,333	2,184,632	408,911	442	CT ST. MARGARET'S-MCTERNAN SCHOOL
47,353	0	NA	0	0	0	0	0	0	3,180	80	33,743	NA	12,330,805	334	MA ST. MARK'S SCHOOL
0	0	1,954	1,811	961	137,481	488,783	0	NA	NA	23	15,199	4,875,396	13,363,370	746	TX ST. MARK'S SCHOOL OF TEXAS
0	0	3,228	2,439	379	123,960	372,040	NA	NA	17,930	10	4,275	3,408,018	3,744,345	723	TX ST. MARY'S HALL
0	0	1,280	180	[illegible]	140	38,023	0	0	0	5	330	NA	0	285	AZ ST. MICHAEL'S COUNTRY DAY SCH.
1,000	381,000	3,495	2,818	[illegible]	175,302	384,294	0	0	17,930	35	19,483	4,017,921	8,211,743	809	MN ST. PAUL ACAD. & SUMMIT SCH.
0	0	1,870	1,480	[illegible]	38,630	161,229	NA	NA	28,000	23	3,623	3,438,377	1,992,544	718	MD ST. PAUL'S SCHOOL
481,037	NA	4,918	3,757	[illegible]	348,236	1,001,317	0	0	0	30	28,781	9,701,808	73,762,287	580	NH ST. PAUL'S SCHOOL
0	0	887	901	300	7,038	41,980	0	0	23,230	5	938	1,137,550	1,042,279	276	MD ST. PAUL'S SCHOOL FOR GIRLS
0	0	1,037	1,287	300	44,330	125,750	0	0	0	25	3,018	1,428,033	[illegible]	244	MA ST. SEBASTIAN'S C. D. SCHOOL
0	0	1,000	1,000	443	38,517	144,467	0	0	0	3	373	NA	888,000	390	FL ST. STEPHEN'S EPISCOPAL SCH.
0	0	1,400	1,204	400	30,443	232,432	NA	NA	NA	10	4,038	3,309,753	1,780,939	400	VA ST. STEPHEN'S SCHOOL
13,523	0	4,370	3,331	1,988	114,990	303,427	16,000	0	2,936	73	13,774	2,444,284	1,276,375	737	MN ST. THOMAS ACADEMY
32,500	13,287	2,730	2,430	1,207	193,383	393,779	0	0	0	34	13,003	2,043,122	4,420,222	141	MD ST. TIMOTHY'S SCHOOL
0	0	2,000	1,900	740	41,171	183,362	0	0	92,187	32	3,943	980,704	940,050	187	NC SALEM ACADEMY
0	0	NA	NA	NA	0	222,970	0	0	0	9	3,337	445,433	40,000	155	CA SAN FRANCISCO DAY SCHOOL
0	0	440	443	75	1,042	119,010	0	0	0	9	2,735	NA	0	340	CA SAN FRANCISCO UNIV. H.S.
0	0	1,889	1,884	404	38,700	318,301	0	0	NA	13	5,000	3,944,470	342,449	401	CA SANTA CATALINA SCHOOL
0	0	1,318	1,430	440	22,043	132,770	3,000	0	0	21	3,391	2,297,993	548,432	863	GA SAVANNAH C. D. SCHOOL
1,433	0	1,018	1,018	340	34,470	110,900	0	0	1,700	13	2,435	1,474,457	491,483	533	KY SAYRE SCHOOL
0	0	3,190	2,044	[illegible]	38,903	33,013	0	800	0	0	0	1,833,818	205,344	775	PA SCRANTON PREPARATORY SCHOOL
0	0	438	400	34	8,123	33,748	0	0	0	0	0	991,991	209,844	218	HI SEABURY HALL
0	23,750	0	0	0	0	0	0	0	0	84	23,738	2,130,341	0	980	CA SERVITE HIGH SCHOOL
190,000	0	3,000	3,000	[illegible]	58,360	301,000	0	0	0	20	2,290	3,934,525	2,148,093	836	OH SEVEN HILLS SCHOOLS
0	0	2,000	2,000	179	21,360	44,309	20	0	13,099	10	2,010	2,131,391	95,232	490	MD SEVERN SCHOOL
0	0	2,093	2,093	704	34,263	171,124	0	0	0	30	10,030	2,721,994	3,780,340	648	PA SEWICKLEY ACADEMY
1,000	0	3,948	3,757	1,333	148,070	303,287	NA	NA	NA	35	19,300	4,718,499	7,300,000	894	PA SHADY SIDE ACADEMY
0	0	487	483	983	3,400	94,774	NA	NA	NA	5	290	1,084,484	260,900	280	DC SHERIDAN SCHOOL
81,230	0	3,060	3,080	1,360	160,484	363,540	0	0	7,147	96	31,070	2,990,000	1,037,192	338	PA SHIPLEY SCHOOL
0	0	1,980	1,380	133	14,411	102,544	0	0	3,734	0	3,195	NA	730,000	486	MA SHORE COUNTRY DAY SCHOOL
0	0	470	470	30	970	112,034	0	0	0	1	400	NA	0	880	FL SHORECREST PREPARATORY SCHOOL
0	0	3,237	3,237	980	85,580	423,034	0	0	0	0	0	4,182,800	1,387,280	1,009	DC SIDWELL FRIENDS SCHOOL
0	0	1,837	1,512	135	21,063	39,840	0	0	4,700	4	630	414,062	170,000	132	PA SOLEBURY SCHOOL
0	0	1,475	1,437	790	94,833	270,427	0	0	NA	43	17,331	1,031,984	1,091,148	172	CT SOUTH KENT SCHOOL
0	0	985	380	[illegible]	1,943	133,454	0	0	0	0	12,523	1,084,062	329,744	340	SC SPARTANBURG DAY SCHOOL
121,430	190,287	2,108	2,150	[illegible]	73,862	419,981	0	0	0	37	23,337	NA	3,100,000	327	NY SPENCE SCHOOL
0	0	1,000	1,090	[illegible]	14,198	38,141	0	0	0	1	25	1,307,216	906,434	167	CN STANSTEAD COLLEGE
0	0	NA	0	[illegible]	0	0	0	0	0	0	0	NA	767,000	475	NY STATEN ISLAND ACADEMY
0	0	4,244	3,362	813	34,370	134,443	0	NA	NA	29	8,030	1,622,833	330,000	[illegible]	GA [illegible] SCHOOL
0	0	3,470	3,369	1,110	144,144	404,404	0	0	0	0	0	3,000,433	2,495,100	[illegible]	NY STONY BROOK SCHOOL
0	0	494	494	0	0	0	0	0	3,000	30	7,087	1,941,237	621,174	[illegible]	NJ STUART COUNTRY DAY SCH. -S.H.
3,000	101,000	2,443	2,443	331	13,440	94,899	0	0	330	0	710	992,892	848,330	[illegible]	VA STUART HALL
0	0	2,400	980	NA	3,143	11,331	0	0	0	0	0	NA	190,380	232	CO STUDY
0	0	2,000	2,000	775	44,710	190,000	0	0	0	0	0	3,334,390	1,200,000	304	CT SUFFIELD ACADEMY

INDEPENDENT SECONDARY AND ELEMENTARY SCHOOLS (CONT.)

[illegible]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SUMMIT SCHOOL	463,469	104,102	28,000	100,153	201,347	26,000	0	61,825	224,577	16,775	6,095	161,617	0	0
SUNSET HILLS	367,032	199,096	5,211	131,032	0	10,901	612	76,366	109,239	25,063	31,500	19,506	0	71,500
TABOR ACADEMY	583,701	380,457	20,565	26,025	145,319	53,000	36,015	203,136	176,748	71,699	38,653	10,350	0	0
TAFT SCHOOL	2,728,671	898,636	10,000	137,000	812,065	828,362	32,000	1,417,818	364,661	98,520	615,303	4,600	0	0
TAMPA PREPARATORY SCHOOL	65,990	65,990	0	0	0	0	0	0	31,766	7,963	16,000	11,319	0	0
TATNALL SCHOOL	393,331	153,622	0	196,703	0	63,289	0	96,630	108,069	71,622	119,503	0	0	75,000
THACHER SCHOOL	1,293,562	373,193	33,728	351,362	453,687	78,000	13,303	762,645	77,240	142,853	303,938	30,296	0	0
THAYER ACADEMY	546,136	192,005	11,626	199,088	0	136,819	0	125,159	131,292	146,820	143,003	16,065	0	0
TILTON SCHOOL	252,399	123,557	6,756	38,203	3,520	88,357	0	101,762	36,223	83,330	33,003	5,067	0	0
TOWER HILL SCHOOL	269,463	149,960	12,900	5,019	62,105	6,064	38,000	96,271	66,962	675	81,003	8,360	0	0
TOWER SCHOOL	231,036	52,232	16,927	162,875	1,000	0	0	535	87,277	143,222	0	0	0	0
TOWN SCHOOL	89,693	81,963	0	0	7,750	0	0	503	63,835	22,303	0	2,975	0	0
TOWN SCHOOL FOR BOYS	783,652	136,757	107,556	405,249	131,936	0	0	69,805	303,567	910	225,303	16,620	0	127,550
TRINITY EPISCOPAL SCHOOL	85,586	31,337	6,106	0	48,143	0	0	570	22,616	16,611	7,550	1,383	0	36,856
TRINITY PREPARATORY SCHOOL	433,285	85,630	28,130	143,267	55,833	120,637	0	6,310	120,056	63,340	130,503	69,631	2,653	46,000
TRINITY SCHOOL OF MIDLAND	313,782	262,966	26,461	63,297	0	0	0	9,793	166,666	33,260	92,503	17,638	0	26,450
TUXEDO PARK SCHOOL	71,000	66,580	380	0	4,000	0	0	6,330	26,502	7,998	12,003	2,250	0	0
UNIVERSITY LIGGETT SCHOOL	732,686	627,776	6,017	61,807	233,020	6,300	0	637,063	128,665	96,260	32,003	11,603	0	27,353
UNIVERSITY SCHOOL	1,962,696	330,373	128,987	132,700	398,073	759,277	0	1,632,057	218,680	72,280	163,300	37,700	0	26,927
UNIVERSITY SCHOOL OF MILWAUKEE	2,779,233	279,205	36,301	1,620,960	185,000	858,707	0	1,806,636	166,761	861,360	305,925	68,607	0	230,177
VAIL-DEANE SCHOOL	106,635	59,569	36,066	0	0	13,000	0	27,925	13,592	16,596	63,506	1,320	0	6,636
VALLEY SCHOOL OF LIGONIER	65,831	66,767	1,066	0	0	0	0	11,007	13,166	6,606	13,503	0	0	1,066
VERDE VALLEY SCHOOL	117,901	105,868	16,233	0	0	0	0	39,080	30,782	42,165	2,000	2,203	0	0
VERMONT ACADEMY	452,532	93,912	32,009	119,807	186,608	0	0	204,635	147,623	62,626	39,030	0	0	0
VIRGINIA EPISCOPAL SCHOOL	1,259,794	231,378	9,730	6,009	1,007,316	6,203	0	279,821	32,616	177,956	725,262	26,901	0	0
WALLACE O'NEAL DAY SCHOOL	227,627	153,266	46,052	23,821	2,666	0	0	699	65,307	163,566	1,075	100	0	0
WAYLAND ACADEMY	362,686	163,629	119,237	22,961	15,101	61,890	6,003	98,517	133,383	20,031	96,775	93,382	0	0
WEBB SCHOOL	1,026,971	168,080	0	0	602,396	662,375	0	636,765	8,756	225,623	366,303	6,600	0	0
WEBB SCHOOL OF KNOXVILLE	462,060	63,039	16,083	0	376,662	31,600	0	71,226	138,336	185,087	25,700	66,695	0	0
WEST NOTTINGHAM ACADEMY	116,231	86,981	0	0	0	47,250	0	65,603	16,269	66,369	0	12,900	0	0
WESTERN RESERVE ACADEMY	1,368,766	321,320	60,752	1,096,066	0	161,000	28,009	373,822	155,780	236,119	521,183	61,662	0	0
WESTLAKE SCHOOL FOR GIRLS	1,028,231	226,165	223,777	578,386	0	0	0	36,331	965,962	0	25,303	0	0	0
WESTMINSTER SCHOOL	1,506,671	316,603	71,376	73,193	616,967	686,272	0	312,269	361,996	30,907	767,151	96,226	2,500	1,953
WESTMINSTER SCHOOLS	1,668,038	582,673	96,323	286,000	0	586,998	0	267,608	178,960	716,286	363,653	0	0	0
WESTOVER SCHOOL	2,303,699	1,093,928	30,715	869,226	11,050	311,102	0	1,312,305	166,556	316,761	503,000	25,297	0	0
WESTRIDGE SCHOOL	605,576	167,683	18,855	202,219	61,769	195,068	0	267,806	38,632	167,693	192,603	7,650	0	0
WESTTOWN SCHOOL	1,272,632	263,770	116,636	627,627	69,666	202,762	36,003	562,006	197,965	215,262	206,767	16,106	26,225	52,061
WHEELER SCHOOL	263,396	121,229	6,778	110,003	0	17,379	0	36,667	117,666	19,136	58,300	3,145	0	31,300
WHEELING COUNTRY DAY SCHOOL	28,635	28,635	0	0	0	0	0	3,760	10,250	14,625	0	0	0	0
WHITBY SCHOOL	111,778	66,385	3,000	22,305	22,003	0	0	272	71,763	26,015	7,300	5,920	0	0
WHITE MOUNTAIN SCHOOL	286,753	156,786	0	0	2,006	68,051	0	16,635	23,718	165,276	69,686	12,663	0	0
WHITEMAN SCHOOL	105,671	68,571	23,100	65,000	0	0	0	6,275	51,630	17,066	10,003	17,500	0	0
WHITFIELD SCHOOL	122,906	122,906	0	0	0	0	0	9,518	13,315	63,281	36,930	1,903	0	0
WILLIAM PENN CHARTER SCHOOL	896,733	200,135	155,590	115	328,951	212,131	0	665,022	143,611	26,326	87,750	35,376	0	0
WILLIAMS SCHOOL	105,133	36,903	9,000	56,633	0	0	0	6,303	69,702	6,133	15,003	2,695	0	0
WILLIAMSON FREE SCH. MECH. TR.	923,565	321,733	10,261	266,122	0	327,729	0	609,686	0	93,659	332,798	26,306	0	0
WILLISTON NORTHAMPTON SCH.	1,087,076	271,286	30,711	97,252	0	635,905	23,000	635,516	166,076	656,183	63,003	26,095	35	6,167
WILMINGTON FRIENDS SCHOOL	360,193	166,790	37,172	85,300	6,916	55,305	0	78,656	79,787	13,336	131,661	2,986	16,010	28,216
WILSON SCHOOL	28,600	28,600	0	0	0	0	0	605	13,761	2,097	0	25	0	12,000
WINCHESTER-THURSTON SCHOOL	218,318	103,932	29,665	15,506	0	69,435	0	56,055	65,266	13,662	95,003	7,777	0	0
WOODBERRY FOREST SCHOOL	3,155,056	1,663,020	166,632	319,302	838,620	169,596	20,003	1,921,903	292,176	106,605	799,258	31,130	0	0
WOODLANDS ACAD. SACRED HEART	212,361	195,086	5,392	0	0	11,663	0	16,789	57,229	63,260	0	3,275	8,000	62,000
WOOSTER SCHOOL	669,225	135,533	0	50,300	198,202	85,110	0	129,301	169,613	76,666	109,020	3,360	0	0
WORCESTER ACADEMY	223,632	127,660	26,059	69,527	0	0	0	113,809	2,073	6,355	59,133	36,155	0	7,690
WYKEHAM RISE SCHOOL	227,267	133,267	35,900	58,100	0	0	0	66,663	66,876	63,921	69,503	6,523	0	0
WYOMING SEMINARY	676,360	196,066	296,013	0	0	265,365	0	203,206	239,626	56,200	16,753	62,191	17,507	0

0	0	3,210	2,000	35	13,505	106,102	0	0	0	78	33,392	1,307,603	864,216	370	DC SUMMIT SCHOOL
0	0	1,237	5,000	335	64,063	304,300	0	0	0	29	19,506	2,133,446	1,772,690	686	MO SUNSET HILLS
0	63,100	6,600	6,000	1,035	163,318	303,037	0	0	NA	65	13,062	4,466,057	2,966,950	316	MA TABOR ACADEMY
133,000	0	3,983	3,042	2,400	600,016	918,444	0	0	137,000	0	0	3,363,028	17,377,690	318	CT TAFT SCHOOL
0	0	230	0	0	0	63,090	0	0	0	3	4,000	NA	15,000	253	FL TAMPA PREPARATORY SCHOOL
0	0	1,322	1,322	233	14,400	142,622	0	0	67,000	0	0	6,082,000	2,023,000	760	DE TATNALL SCHOOL
12,000	21,000	2,190	1,730	996	233,871	406,713	NA	0	NA	28	23,096	2,634,829	6,762,100	222	CA THACHER SCHOOL
6,000	2,171	3,943	4,532	1,236	81,711	192,003	0	0	0	68	14,613	3,090,000	2,709,599	372	MA THAYER ACADEMY
3,020	0	4,067	4,001	691	63,017	123,557	0	0	0	27	2,067	1,212,000	2,030,000	265	NH TILTON SCHOOL
0	0	2,610	4,010	931	86,283	162,608	0	0	NA	23	2,060	3,000,000	8,030,000	665	DE TOWER HILL SCHOOL
0	0	NA	0	0	0	0	0	0	2,360	0	0	931,004	7,520	190	MA TOWER SCHOOL
3,000	0	900	90	0	363	81,963	0	0	NA	8	2,973	NA	0	330	NY TOWN SCHOOL
0	0	1,334	1,334	990	11,095	138,717	0	1,500	0	10	9,616	1,627,334	1,954,713	396	CA TOWN SCHOOL FOR BOYS
0	0	NA	NA	6	470	32,043	0	0	0	0	0	NA	0	390	TX TRINITY EPISCOPAL SCHOOL
304,130	0	732	333	69	3,310	83,630	NA	0	13,000	3	630	1,594,979	721,037	614	FL TRINITY PREPARATORY SCHOOL
0	0	NA	0	0	0	0	0	0	0	0	0	1,021,916	1,340,076	656	TX TRINITY SCHOOL OF MIDLAND
0	0	630	600	37	6,130	91,000	0	0	0	4	2,230	NA	224,562	166	NY TUXEDO PARK SCHOOL
32,306	0	6,000	6,000	1,061	262,206	400,421	0	1,300	4,300	20	10,993	3,004,667	7,993,017	910	MI UNIVERSITY LIGGETT SCHOOL
91,373	NA	6,061	3,930	1,739	308,003	831,680	0	4,250	23,300	47	37,700	6,084,623	3,633,000	780	OH UNIVERSITY SCHOOL
850,707	0	7,100	3,000	800	133,930	299,032	0	0	0	20	19,030	3,792,234	4,460,000	717	WI UNIVERSITY SCHOOL OF MILWAUKEE
11,000	0	800	800	170	16,925	63,633	0	0	0	6	1,320	932,920	319,000	176	NJ VAIL-DEANE SCHOOL
0	0	580	525	26	11,097	63,831	0	0	0	0	0	925,091	6,001,978	165	PA VALLEY SCHOOL OF LIGONIER
0	0	1,099	921	267	30,909	117,101	0	0	16,125	0	2,265	1,224,959	170,000	112	AZ VERDE VALLEY SCHOOL
0	0	NA	0	0	0	0	0	0	16,605	0	0	2,066,372	718,976	263	VT VERMONT ACADEMY
1,000	0	2,330	2,300	904	130,030	261,300	0	0	NA	66	14,171	1,937,060	3,021,762	266	VA VIRGINIA EPISCOPAL SCHOOL
0	0	128	128	30	698	66,061	0	0	0	0	0	723,387	22,362	196	NC WALLACE O'NEAL DAY SCHOOL
6,000	0	3,278	3,178	300	63,364	299,108	10,196	0	18,634	18	28,560	3,023,631	2,190,996	289	WI WAYLAND ACADEMY
282,300	61,707	2,163	2,163	700	122,309	160,000	0	0	0	6	6,600	1,007,230	1,700,000	269	TN WEBB SCHOOL
0	0	1,992	1,992	85	3,600	60,822	NA	129	NA	0	0	2,981,312	965,851	725	TN WEBB SCHOOL OF KNOXVILLE
0	0	1,300	1,300	190	30,163	66,901	0	0	0	10	2,090	NA	169,266	122	MD WEST NOTTINGHAM ACADEMY
0	0	3,367	3,062	1,333	163,216	382,000	NA	NA	NA	85	19,715	4,117,352	17,736,420	365	OH WESTERN RESERVE ACADEMY
0	0	2,500	2,131	391	33,166	449,963	0	0	70,000	13	3,095	3,760,960	330,000	680	CA WESTLAKE SCHOOL FOR GIRLS
0	NA	2,687	2,379	800	133,960	308,057	0	0	25,987	132	36,382	2,001,533	6,067,858	341	CT WESTMINSTER SCHOOL
21,000	0	7,325	6,377	2,383	200,006	339,000	0	0	7,700	110	9,631	8,009,083	11,216,012	1,688	GA WESTMINSTER SCHOOLS
731,343	0	2,983	2,875	1,575	282,337	378,348	0	0	36,600	36	25,097	2,060,326	3,269,368	172	CT WESTOVER SCHOOL
0	0	2,200	2,000	782	67,062	164,336	0	0	0	27	3,930	NA	2,000,000	339	CA WESTRIDGE SCHOOL
27,290	916,673	6,344	3,328	1,930	163,262	263,778	0	0	0	86	16,106	4,265,131	10,030,000	622	PA WESTTOWN SCHOOL
1,000	0	2,600	2,600	601	22,537	123,963	0	0	4,000	11	1,043	3,683,000	677,333	366	RI WHEELER SCHOOL
NA	NA	305	273	23	3,768	28,051	NA	NA	NA	NA	NA	NA	72,503	230	WV WHEELING COUNTRY DAY SCHOOL
0	0	410	250	7	278	63,303	0	0	6,000	18	3,920	918,987	63,381	260	CT WHITBY SCHOOL
2,000	0	1,367	1,108	267	16,635	156,706	0	0	0	32	12,640	1,311,211	611,036	112	NH WHITE MOUNTAIN SCHOOL
0	0	267	267	67	9,079	103,671	0	0	0	NA	1,000	NA	0	73	CO WHITEMAN SCHOOL
0	0	330	390	178	9,318	122,964	0	0	0	6	900	673,202	34,027	71	MO WHITFIELD SCHOOL
76,079	NA	3,310	3,206	1,036	173,787	259,392	0	NA	0	102	23,376	1,631,192	6,926,092	770	PA WILLIAM PENN CHARTER SCHOOL
0	0	2,002	2,002	175	3,721	20,903	3,000	0	60,020	16	2,670	922,167	223,662	219	CT WILLIAMS SCHOOL
72,951	NA	2,327	2,327	996	171,106	662,993	0	0	0	30	22,606	1,039,656	9,639,170	0	PA WILLIAMSON FREE SCH. MECH. TR.
366,196	0	7,000	6,000	1,000	103,306	310,917	0	0	0	92	27,166	4,336,300	6,787,197	301	MA WILLISTON NORTHAMPTON SCH.
3,000	0	2,600	2,702	950	98,323	141,630	0	0	3,390	26	2,636	3,096,323	2,220,382	647	DE WILMINGTON FRIENDS SCHOOL
0	0	NA	0	0	0	0	0	0	0	0	0	NA	0	178	MD WILSON SCHOOL
6,000	0	2,365	2,363	866	32,000	133,377	0	0	936	26	6,829	2,660,423	1,340,330	687	PA WINCHESTER-THURSTON SCHOOL
876,637	0	3,000	3,717	2,360	436,110	798,033	0	0	0	97	33,130	6,083,730	17,616,140	366	VA WOODBERRY FOREST SCHOOL
NA	NA	2,000	1,000	800	10,789	123,000	0	0	0	11	3,073	NA	20,000	190	IL WOODLANDS ACAD. SACRED HEART
18,900	0	1,643	1,310	363	33,010	133,333	0	NA	NA	58	12,397	1,020,077	338,666	235	CT WOOSTER SCHOOL
27,190	0	3,019	3,226	1,129	86,001	161,026	0	26,000	0	67	6,033	3,620,613	1,370,171	605	MA WORCESTER ACADEMY
0	0	600	600	135	66,661	166,767	0	0	0	0	0	932,938	0	66	CT WYKEHAM RISE SCHOOL
66,000	NA	7,070	7,200	1,800	116,097	179,137	12,000	0	9,170	67	14,331	1,199,100	6,963,300	636	PA WYOMING SEMINARY

Independent Secondary and Elementary Schools

Survey Results

- The 451 schools in the survey received $280 million in gifts in 1983-84, an increase over the $276 million reported by 480 schools in 1982-83
- The 1983-84 average per school of $621,107 was a 7.9 percent increase over the 1982-83 average of $575,462
- The year-to-year increase of the 371 schools in both the 1982-83 and the 1983-84 surveys was 6.6 percent, which outpaced inflation
- Gifts from individuals accounted for 75.5 percent of all gifts. Over half of corporate support came from matching gifts and gifts of company products or other property
- A record 25.8 percent of alumni/ae responded to annual-fund drives and increased their average gift by 6.8 percent to a record $229.21

A total of 451 schools participated in the 1983-84 survey and reported receiving $280,119,367 in gifts, an increase over the $276,221,734 received by the 480 schools in the 1982-83 survey. The average of $621,107 per school in 1983-84 represented a 7.9 percent increase over the $575,462 average in 1982-83.

The 1983-84 survey was restructured in several ways. A new donor group—parents—was added; more details about the nature of gifts were asked for; and the donor purposes, especially for capital gifts, were revised to reflect more accurately the way funds are raised and school accounts are kept.

For the first time the schools are being grouped with their peers, using the following NAIS classifications:

Day elementary
Day elementary/secondary
Day secondary
Day/boarding—are primarily day schools that enroll some boarding students
Boarding and Boarding/day—enroll boarding students only, in the first case, or enroll some day students in the second

These five classifications are then further broken down according to the sex of the students. This restructuring will help development officers and school administrators to evaluate their activities more effectively and also more easily to compare results with peers and with other school groupings. The first result of this restructuring is the analysis presented in *Table 12*.

The most successful schools in garnering voluntary support were the eight reporting Boarding and Boarding/day schools for girls. These averaged over $2 million each. The 18 boys schools and the 80 coed schools in this category averaged $1 million each. Overall, the 58 boys schools in all five categories averaged over $800,000 each, the 70 girls schools over $660,000 and the 323 coed schools over $578,000 each.

The examination of giving by schools in *Table 13* also benefits from the more precise analysis made possible by the new survey classifications. Parents turn out to be the most important single source of gifts for all three groups of day schools, although by only a small margin over alumni/ae for the Day elementary/secondary and Day secondary schools. Alumni/ae, as expected, led all the rest in giving to the boarding schools.

Table 12. Total Voluntary Support by Type of Independent School, 1983-84

Type of School	Girls	Boys	Coeducational	Total
Day Elementary	$ —	$ 1,404,789 (3)	$ 11,039,925 (60)	$ 12,444,714 (63)
Day Elementary/Secondary	17,456,516 (34)	11,375,459 (15)	67,570,043 (120)	96,402,018 (169)
Day Secondary	3,347,389 (8)	10,577,754 (16)	8,790,970 (30)	22,716,113 (54)
Day/Boarding	8,817,757 (10)	5,540,442 (6)	17,317,308 (33)	31,675,507 (49)
Boarding and Boarding/Day	16,730,196 (8)	18,044,837 (18)	82,085,892 (80)	116,860,925 (116)
GRAND TOTAL	$46,371,858 (70)	$46,943,281 (58)	$186,804,228 (323)	$280,119,367 (451)

(Figures in parentheses show number of schools reporting.)

Table 13. Sources of Voluntary Support by Type of Independent School, 1983-84

	Individuals			Organizations			
Type of School	Alumni	Parents	Other Individuals	Foundations	Corporations	Religious Organizations	Other Sources
Day Elementary	$ 937,715	$ 6,580,909	$ 1,801,707	$ 1,814,982	$ 431,186	$ 19,420	$ 880,885
Day Elementary/Secondary	26,086,145	28,865,934	17,229,937	14,675,087	4,810,571	295,819	4,454,915
Day Secondary	5,086,544	6,144,381	5,582,719	2,882,253	1,037,084	892,028	1,140,404
Day/Boarding	11,465,885	8,001,746	4,774,330	4,442,147	1,225,809	308,830	1,448,860
Boarding and Boarding/Day	58,381,675	17,889,577	12,710,123	21,740,282	4,134,063	690,516	1,406,089
GRAND TOTAL	$101,857,984	$87,448,547	$42,377,816	$45,355,371	$11,640,313	$2,157,303	$9,349,153

(Dollars in thousands)

Table 14. Voluntary Support of Independent Schools for Current Operations and Capital Purposes by Source of Support, 1983-84

	Individuals			Organizations			
Purposes	Alumni/ae	Parents	Other Individuals	Foundations	Corporations	Religious Organizations	Other Sources
CURRENT OPERATIONS							
Unrestricted	$ 36,190,611 (35.5)	$31,984,733 (47.4)	[illegible] ([illegible])	$ 4,651,905 (10.3)	$ 5,221,666 (44.8)	$1,689,214 (74.5)	$2,736,340 (29.3)
Restricted	5,163,066 (5.1)	5,156,549 (7.6)	3,436,309 (8.1)	5,392,240 (11.9)	1,334,051 (11.5)	305,194 (16.7)	2,785,711 (29.8)
TOTAL	$ 41,353,677 (40.6)	$37,1[illegible] (55.0)	$15,642,405 (37.0)	$10,044,145 (22.2)	$ 6,555,717 (56.3)	$1,994,408 (91.2)	$5,522,051 (59.1)
CAPITAL PURPOSES							
Property, Buildings & Equipment	$32,368,252 ([illegible])	$15,384,466 (22.7)	$12,171,576 (28.8)	$14,027,001 (30.9)	$ 3,027,966 (26.0)	$ 70,009 (3.2)	$1,330,802 (14.1)
Endowment–Income Unrestricted	21,167,326 (20.8)	8,380,277 (12.4)	7,460,597 (17.7)	7,189,417 (15.9)	1,066,142 (9.2)	5,500 (0.3)	1,590,815 (17.0)
Endowment–Income Restricted	16,361,937 (16.1)	6,402,477 (9.4)	6,984,395 (16.4)	[illegible] ([illegible])	943,773 (8.1)	117,296 (5.4)	854,562 (9.1)
Loan Funds	606,772 (0.6)	214,065 (0.3)	78,753 (0.2)	1,136,125 (2.5)	54,415 (0.4)	— —	60,923 (0.7)
TOTAL	$ [illegible] ([illegible])	$30,[illegible] (45.0)	$26,635,321 (63.0)	$35,311,226 (77.8)	$ 5,093,596 (43.7)	$ 192,795 (8.8)	$3,827,102 (40.9)
GRAND TOTAL	$101,[illegible] (100.0)	$67,442,547 (100.0)	$42,277,816 ([illegible])	$45,355,371 (100.0)	$11,649,313 (100.0)	$2,187,203 (100.0)	$9,349,153 (100.0)

(Figures in parentheses show percent of total in each column.)

The Ten Boarding or Boarding/Day Schools Reporting the Highest Totals of:

Alumni/ae Contributions to the Annual Fund

Phillips Exeter Academy (NH)	$1,397,166
Phillips Academy (MA)	1,378,960
Deerfield Academy (MA)	1,057,313
The Hotchkiss School (CT)	906,112
The Lawrenceville School (NJ)	899,402
Choate Rosemary Hall (CT)	719,442
The Taft School (CT)	660,616
The Hill School (PA)	629,615
Northfield Mount Hermon School (MA)	628,608
St. Paul's School (NH)	562,236

Gifts for Capital Purposes

The Culver Academies (IN)	$3,448,901
St. Paul's School (NH)	3,230,011
Phillips Exeter Academy (NH)	2,882,053
The Lawrenceville School (NJ)	2,813,782
The Kiskiminetas Springs School (PA)	2,720,329
Phillips Academy (MA)	2,766,734
The Hotchkiss School (CT)	2,277,582
Choate Rosemary Hall (CT)	2,096,066
Emma Willard School (NY)	1,865,713
The Taft School (CT)	1,810,027

Meaningful comparisons between two years are difficult because of the different number and types of schools in each survey. Calculating average amounts received by each school compensates for the numerical differences but masks differences in characteristics. A group of schools participating in two consecutive surveys is necessary for real comparisons. Only these "core" schools, even though a smaller group, can provide concrete data on the nature of the year-to-year changes in voluntary support.

A total of 371 schools served as the "core" group in this survey (see Appendix Table D for complete details of their reports). They recorded an increase of 6.6 percent in total support in 1983-84 over 1982-83. This increase, greater than the 3.7 percent inflation rate as measured by the CPI, was good news for the schools. Gifts from alumni/ae rose 12.6 percent and from other individuals 8.3 percent. Foundations and corporations, on the other hand, both decreased their support—by 2.4 percent and 5.8 percent, respectively. Contributions for current operations grew by 14.2 percent, while those for capital purposes remained almost the same. Support for boys schools surged by 18.9 percent, the coeducational and girls schools each reported much smaller increases.

Alumni/ae gifts to the *annual fund* have always been important to independent schools. In 1983-84 they totaled $36,679,678 and accounted for 36.0 percent of all alumni/ae contributions. More alumni/ae—25.8 percent—responded to the annual-fund drives in 1983-84 than in any previous year, and they increased their average gift by 6.8 percent to a record $129.21. Individuals often use *bequests* and *deferred gifts*, such as trusts, pooled income funds and gift annuities, as part of their estate plans to support independent schools. These gifts increased in 1983-84, so that they provided 8.9 percent of all contributions from individuals and 6.8 percent of total contributions to the schools. Corporations contributed to the independent schools through *matching-gift programs* and by making grants of *company products* and other *physical property*, as well as through cash gifts. Corporate funds from matched gifts declined slightly in 1983-84 to $4,227,380, but gifts of both company products ($1,451,120) and other property ($566,463) increased sharply. In 1983-84 matching gifts and property donations accounted for 53.6 percent of all corporate support of independent schools. The share in 1982-83 was 44.3 percent. An additional $3,380,715 in gifts of property from sources other than corporations flowed to the schools.

Because of the differences in the categories for reporting donor purposes in the 1983-84 survey, exact comparisons with previous years are not feasible. *Table 14*, however, presents data about voluntary support for current operations and capital purposes, by source of support.

Historically, alumni/ae and other individuals have provided about 70 percent of the private support of the independent schools. Foundations have been other large benefactors, donating about 18 percent of all support. The

The Ten Day or Day/Boarding Schools Reporting the Highest Totals of:

Alumni/ae Contributions to the Annual Fund

Regis High School (NY)	$481,886
Milton Academy (MA)	426,861
University School (OH)	398,865
Punahou School (HI)	386,330
The Baylor School (TN)	322,984
The Kinkaid School (TX)	290,545
The Loomis Chaffee School (CT)	281,513
The McCallie School (TN)	279,257
St. Ignatius High School (OH)	244,953
University Liggett School (MI)	242,296

Gifts For Capital Purposes

University School of Milwaukee (WI)	$2,465,667
St. John's School (TX)	2,090,994
The Brearley School (NY)	2,021,665
The Hockaday School (TX)	1,952,394
The Kinkaid School (TX)	1,782,311
The Pingry School (NJ)	1,447,515
Polytechnic School (CA)	1,382,728
Dana Hall School (MA)	1,364,759
Montgomery Bell Academy (TN)	1,296,954
University School (OH)	1,262,132

pattern in 1983-84 showed a slight variation. More than three quarters of all support came from individuals, with alumni/ae supplying the largest percentage (38.4), parents the next (24.1), and other individuals giving the rest (15.1). Foundation and corporate gifts declined slightly, so their shares of total support were also smaller (16.2 percent for foundations versus 18.6 percent in 1982-83 and 4.2 percent versus last year's 4.8 percent for corporations).

Traditionally, more than half of the gifts to the independent schools have been made with no restrictions about how they are to be used. Combining the totals for unrestricted current-operations gifts with those for endowment with no restrictions on the use of its income produces an approximate measure of "unrestricted" gifts. They totaled 30.5 percent of all support in 1983-84. Parents and corporations preferred to make gifts without restrictions for current operations, while alumni/ae, other individuals and foundations favored gifts for capital purposes.

Further breakdowns of donor purposes will be possible in the future, as more data are accumulated.

Institutions Reporting the Highest Totals

The 20 Colleges and Universities Reporting the Most Voluntary Support:*

Harvard University	$125,201,403
Stanford University	111,802,741
Yale University	75,336,008
Columbia University	75,234,746
Cornell University	72,818,654
California, University of–Los Angeles	64,076,015
Massachusetts Institute of Technology	62,904,898
Pennsylvania, University of	60,036,447
Princeton University	56,163,839
Southern California, University of	55,080,784
Chicago, University of	54,877,359
Illinois, University of	53,203,394
Wisconsin, University of–Madison	52,460,347
Michigan, University of	52,072,055
Texas A & M University	48,147,936
Minnesota, University of	47,351,681
New York University	45,266,695
Johns Hopkins University	42,322,416
Washington, University of	41,255,361
Washington University	40,751,355

*Not included are two systems, each comprising multiple units:

California, University of–Summary	172,638,445
Texas, University of–Summary	106,578,086

The 20 Colleges and Universities Reporting the Most Corporate Support:*

California, University of–Los Angeles	$30,834,214
Stanford University	29,234,745
Massachusetts Institute of Technology	27,915,654
Harvard University	25,580,322
Illinois, University of	20,957,647
California, University of–Berkeley	18,223,409
Wisconsin, University of–Madison	16,329,412
Southern California, University of	15,153,481
Michigan, University of	14,638,604
Cornell University	14,334,465
Columbia University	13,787,731
Pennsylvania, University of	13,495,453
Texas A & M University	13,465,231
Minnesota, University of	13,035,510
Florida, University of	12,332,047
Georgia, University of	12,239,221
Carnegie-Mellon University	11,107,772
Duke University	10,958,165
Rensselaer Polytechnic Institute	10,902,092
Missouri, University of	10,549,146

*Not included are two systems, each comprising multiple units:

California, University of–Summary	71,614,783
Texas, University of–Summary	23,905,491

The Ten Schools Reporting the Most Voluntary Support:

Phillips Academy (MA)	$4,956,755
Phillips Exeter Academy (NH)	4,612,836
The Culver Academies (IN)	4,471,808
St. Paul's School (NH)	4,348,125
The Lawrenceville School (NJ)	4,145,777
The Hotchkiss School (CT)	3,683,430
Choate Rosemary Hall (CT)	3,595,296
Woodberry Forest School (VA)	3,155,086
The Kiskiminetas Springs School (PA)	2,888,888
Deerfield Academy (MA)	2,813,669

The Ten Schools Reporting the Most Corporate Support:

The American School in Japan	$803,739
The Blake Schools (MN)	417,441
The Leelanau School (MI)	313,444
Forsyth Country Day School (NC)	303,121
Punahou School (HI)	283,272
Phillips Academy (MA)	256,169
Phillips Exeter Academy (NH)	238,332
The Culver Academies (IN)	187,313
Choate Rosemary Hall (CT)	186,267
Marine Military Academy (TX)	179,077

Table A VOLUNTARY SUPPORT RECEIVED IN 1983-84, ALL COLLEGES AND UNIVERSITIES REPORTING

(Including percentage of Grand Total in parentheses; dollars in thousands)

PRIVATE INSTITUTIONS

	DOCTORAL	COMPRE-HENSIVE	GENERAL BACCA-LAUREATE	SPE-CIALIZED	SUBTOTAL FOUR-YEAR	TWO-YEAR	ALL INSTITUTIONS
NUMBER OF INSTITUTIONS	56	131	411	109	707	42	749
GRAND TOTAL OF SUPPORT	$1,591,294 (100.0)	$487,018 (100.0)	$851,449 (100.0)	$196,074 (100.0)	$3,125,835 (100.0)	$20,610 (100.0)	$3,146,445 (100.0)
PURPOSES OF SUPPORT							
CURRENT OPERATIONS - UNRESTRICTED	$225,171 (14.1)	$142,129 (29.2)	$306,070 (36.0)	$63,067 (32.2)	$736,437 (23.6)	$9,484 (46.0)	$746,101 (23.7)
CURRENT OPERATIONS - RESTRICTED	$679,600 (42.6)	$89,574 (18.4)	$126,325 (14.8)	$51,633 (26.3)	$947,135 (30.3)	$2,581 (12.5)	$949,716 (30.2)
CAPITAL - PROPERTY, BUILDINGS & EQUIPMENT	$217,972 (13.7)	$106,651 (21.9)	$165,360 (19.4)	$41,029 (20.9)	$531,225 (17.0)	$5,552 (26.9)	$536,777 (17.1)
ENDOWMENT - INCOME UNRESTRICTED	$64,947 (4.1)	$36,031 (7.4)	$97,801 (11.4)	$14,217 (7.3)	$213,500 (6.8)	$883 (4.3)	$214,383 (6.8)
ENDOWMENT - INCOME RESTRICTED	$393,404 (24.6)	$110,521 (22.7)	$165,616 (19.4)	$24,437 (12.5)	$692,974 (22.1)	$2,000 (9.7)	$694,983 (22.0)
LOAN FUNDS	$15,780 (1.0)	$1,497 (0.3)	$4,180 (0.5)	$517 (0.3)	$21,502 (0.7)	$1 (0.0)	$21,503 (0.7)
SOURCES OF SUPPORT							
ALUMNI/AE	$428,948 (26.9)	$118,401 (24.3)	$255,712 (29.7)	$29,204 (15.0)	$832,385 (26.5)	$3,085 (15.0)	$835,470 (26.6)
PARENTS	$12,412 (0.8)	$11,462 (2.4)	$26,104 (3.0)	$1,019 (0.5)	$51,056 (1.6)	$380 (1.8)	$51,437 (1.6)
OTHER INDIVIDUALS	$326,513 (20.5)	$133,061 (27.3)	$222,790 (25.9)	$46,360 (23.9)	$727,713 (23.2)	$5,821 (28.3)	$733,533 (23.2)
FOUNDATIONS	$360,938 (22.6)	$94,237 (19.3)	$136,099 (15.9)	$45,467 (23.3)	$637,441 (20.3)	$3,777 (18.3)	$641,422 (20.3)
CORPORATIONS & BUSINESSES	$351,617 (22.0)	$71,447 (14.7)	$91,287 (10.8)	$40,132 (20.6)	$557,083 (17.7)	$2,616 (12.7)	$559,697 (17.7)
RELIGIOUS ORGANIZATIONS	$11,030 (0.7)	$36,256 (7.4)	$81,140 (9.4)	$23,300 (12.0)	$152,691 (4.9)	$4,440 (21.6)	$157,072 (5.0)
OTHER ORGANIZATIONS	$106,986 (6.6)	$21,168 (4.3)	$45,515 (5.3)	$8,602 (4.4)	$180,362 (5.7)	$472 (2.3)	$180,853 (5.7)
TYPES OF GIVING							
REALIZED BEQUESTS	$202,137 (12.7)	$75,348 (15.5)	$118,130 (13.7)	$12,924 (6.6)	$408,538 (13.0)	$1,298 (6.3)	$409,836 (13.0)
TRUSTS, POOLED INCOME FUNDS & ANNUITIES	$25,300 (1.6)	$16,221 (3.3)	$21,015 (2.5)	$3,743 (1.9)	$66,782 (2.1)	$203 (1.0)	$66,985 (2.1)
THE ANNUAL FUND							
TOTAL ALUMNI/AE OF RECORD	3,977,075	3,393,696	3,727,170	737,392	11,037,296	267,057	11,304,353
NUMBER SOLICITED	3,205,017	2,106,260	3,187,990	649,839	9,227,962	212,415	9,440,357
NUMBER OF DONORS	912,720	482,707	853,321	139,071	2,388,420	26,047	2,413,277
ALUMNI/AE GIFTS	$168,322	$51,060	$96,953	$14,193	$325,537	$1,625	$327,162
TOTAL GIFTS	$372,777	$126,109	$242,100	$43,516	$784,910	$7,419	$792,389
GIFTS OF PROPERTY							
COMPANY PRODUCTS	$41,282	$3,036	$6,436	$3,745	$54,499	$136	$54,634
OTHER PROPERTY FROM CORPS.	$2,229	$4,433	$6,476	$2,601	$15,936	$76	$16,012
OTHER PROPERTY FROM OTHERS	$26,049	$13,757	$14,569	$1,377	$55,753	$5,391	$61,144
CORP. MATCHING GIFTS							
NUMBER OF GIFTS MATCHED	90,080	41,997	73,861	17,335	223,201	1,911	225,112
AMOUNT MATCHED	$26,187	$10,310	$21,499	$3,612	$59,327	$309	$59,636
VITAL STATISTICS							
EDUCATION & GENL. EXPEND.	$9,012,406	$3,083,862	$3,424,016	$1,282,167	$16,807,451	$112,335	$16,919,946
NO. INSTIT. REPORTING	55	133	401	99	688	37	725
ENDOWMENT	$16,333,177	$3,030,312	$3,049,074	$1,161,936	$23,582,220	$69,797	$23,652,017
NO. INSTIT. REPORTING	56	131	402	100	689	31	720

PUBLIC INSTITUTIONS

	DOCTORAL	COMPRE-HENSIVE	GENERAL BACCA-LAUREATE	SPE-CIALIZED	SUBTOTAL FOUR-YEAR	TWO-YEAR	ALL INSTITUTIONS
NUMBER OF INSTITUTIONS	96	126	39	14	275	94	369
GRAND TOTAL OF SUPPORT	$1,263,763 (100.0)	$118,095 (100.0)	$25,312 (100.0)	$116,906 (100.0)	$1,504,056 (100.0)	$14,637 (100.0)	$1,518,693 (100.0)
PURPOSES OF SUPPORT							
CURRENT OPERATIONS - UNRESTRICTED	$92,312 (7.4)	$19,492 (16.5)	$4,844 (19.1)	$7,218 (6.2)	$123,867 (8.2)	$3,316 (22.7)	$127,183 (8.4)
CURRENT OPERATIONS - RESTRICTED	$735,666 (58.2)	$66,521 (56.3)	$10,565 (41.7)	$69,761 (59.7)	$882,495 (58.7)	$5,095 (34.8)	$887,590 (58.4)
CAPITAL - PROPERTY, BUILDINGS & EQUIPMENT	$173,973 (13.8)	$12,063 (10.2)	$2,476 (9.8)	$26,160 (22.4)	$214,672 (14.3)	$3,070 (21.0)	$217,742 (14.3)
ENDOWMENT - INCOME UNRESTRICTED	$31,340 (2.5)	$1,442 (1.2)	$2,392 (9.5)	$125 (0.1)	$35,299 (2.3)	$1,360 (9.3)	$36,659 (2.4)
ENDOWMENT - INCOME RESTRICTED	$203,341 (16.1)	$18,333 (15.5)	$5,024 (19.9)	$11,894 (10.2)	$238,619 (15.9)	$1,759 (12.0)	$240,378 (15.8)
LOAN FUNDS	$7,150 (0.6)	$201 (0.2)	$8 (0.0)	$1,744 (1.5)	$9,103 (0.6)	$36 (0.2)	$9,141 (0.6)
SOURCES OF SUPPORT							
ALUMNI/AE	$218,023 (17.3)	$20,107 (17.0)	$5,896 (23.3)	$8,962 (7.7)	$252,990 (16.8)	$1,115 (7.6)	$254,105 (16.7)
PARENTS	$2,531 (0.2)	$371 (0.3)	$189 (0.7)	$56 (0.0)	$3,345 (0.2)	$27 (0.2)	$3,372 (0.2)
OTHER INDIVIDUALS	$234,032 (18.5)	$35,183 (29.8)	$7,107 (28.1)	$22,289 (19.1)	$300,602 (20.0)	$5,499 (37.6)	$306,101 (20.2)
FOUNDATIONS	$204,508 (16.4)	$17,200 (14.6)	$3,267 (12.9)	$41,640 (35.6)	$266,615 (17.7)	$1,630 (11.1)	$268,245 (17.7)
CORPORATIONS & BUSINESSES	$424,535 (34.1)	$34,623 (29.3)	$6,024 (23.8)	$30,335 (25.9)	$495,517 (32.9)	$5,226 (35.7)	$500,743 (33.0)
RELIGIOUS ORGANIZATIONS	$542 (0.0)	$73 (0.1)	$20 (0.1)	$31 (0.0)	$667 (0.0)	$18 (0.1)	$685 (0.0)
OTHER ORGANIZATIONS	$157,848 (12.5)	$10,336 (8.8)	$2,820 (11.2)	$13,590 (11.6)	$184,320 (12.3)	$1,122 (7.7)	$185,442 (12.2)
TYPES OF GIVING							
REALIZED BEQUESTS	$89,907 (7.1)	$4,950 (4.2)	$1,000 (4.0)	$6,347 (5.4)	$101,803 (6.8)	$1,301 (8.9)	$103,106 (6.8)
TRUSTS, POOLED INCOME FUNDS & ANNUITIES	$12,763 (1.0)	$2,453 (2.1)	$217 (0.9)	$27 (0.0)	$15,463 (1.0)	$721 (4.9)	$16,184 (1.1)
THE ANNUAL FUND							
TOTAL ALUMNI/AE OF RECORD	9,818,772	3,232,117	283,793	196,015	13,331,697	297,821	13,629,518
NUMBER SOLICITED	7,267,358	2,213,603	232,607	151,272	9,864,972	104,886	9,969,858
NUMBER OF DONORS	1,063,590	263,346	46,860	37,260	1,411,053	6,087	1,417,140
ALUMNI/AE GIFTS	$90,916	$11,328	$2,700	$3,396	$108,427	$956	$109,383
TOTAL GIFTS	$222,041	$32,880	$8,064	$9,695	$270,440	$3,293	$273,733
GIFTS OF PROPERTY							
COMPANY PRODUCTS	$48,144	$5,383	$1,103	$4,699	$59,329	$2,905	$62,234
OTHER PROPERTY FROM CORPS.	$15,903	$7,906	$1,280	$631	$25,260	$1,707	$26,967
OTHER PROPERTY FROM OTHERS	$44,371	$9,074	$2,404	$661	$56,969	$1,561	$58,531
CORP. MATCHING GIFTS							
NUMBER OF GIFTS MATCHED	73,786	9,022	1,227	6,710	90,745	165	90,910
AMOUNT MATCHED	$15,399	$1,967	$334	$1,182	$19,083	$37	$19,121
VITAL STATISTICS							
EDUCATION & GENL. EXPEND.	$17,951,996	$3,494,441	$441,862	$1,327,565	$23,216,062	$990,094	$24,206,156
NO. INSTIT. REPORTING	87	96	29	17	227	66	293
ENDOWMENT	$3,976,216	$196,274	$77,016	$165,635	$4,415,143	$47,543	$4,462,686
NO. INSTIT. REPORTING	83	102	30	14	229	60	289

Table B VOLUNTARY SUPPORT RECEIVED IN 1983-84 BY COLLEGES AND UNIVERSITIES REPORTING IN TWO SURVEY YEARS, BY SOURCE AND BY PURPOSE

(Figures in parentheses are percentage changes in 1983-84 as compared to 1982-83; dollars in thousands)

	PRIVATE INSTITUTIONS							PUBLIC INSTITUTIONS						
	DOCTORAL	COMPREHENSIVE	GENERAL BACCALAUREATE	SPECIALIZED	SUBTOTAL FOUR-YEAR	TWO-YEAR	ALL INSTITUTIONS	DOCTORAL	COMPREHENSIVE	GENERAL BACCALAUREATE	SPECIALIZED	SUBTOTAL FOUR-YEAR	TWO-YEAR	ALL INSTITUTIONS
NUMBER OF INSTITUTIONS	55	127	374	79	635	31	666	83	96	29	16	224	58	2
SOURCES OF SUPPORT														
ALUMNI/AE	$428,986 (11.0)	$116,348 (6.9)	$248,827 (8.7)	$23,774 (-6.8)	$818,073 (6.2)	$2,783 (-26.3)	$820,856 (6.0)	$204,895 (3.6)	$16,260 (31.4)	$3,470 (9.0)	$8,897 (38.4)	$233,649 (5.2)	$1,032 (191.5)	$236,4 (5.5)
OTHER INDIVIDUALS	$335,461 (16.9)	$142,963 (20.0)	$216,936 (1.8)	$33,863 (-10.7)	$748,403 (12.5)	$5,511 (0.1)	$753,914 (12.6)	$227,975 (19.2)	$31,069 (-2.0)	$6,071 (90.9)	$21,404 (-6.2)	$286,966 (14.7)	$3,122 (37.5)	$290,0 (14.
FOUNDATIONS	$360,119 (6.4)	$92,361 (11.1)	$129,027 (3.7)	$16,671 (-6.6)	$599,210 (5.8)	$3,362 (35.0)	$602,601 (5.9)	$192,157 (7.3)	$16,880 (1.2)	$2,911 (38.1)	$39,131 (6.1)	$248,409 (7.8)	$1,182 (44.6)	$249,5 (7.
CORPORATIONS	$331,290 (13.3)	$70,379 (2.2)	$89,881 (8.3)	$29,961 (23.4)	$540,280 (11.4)	$2,404 (37.0)	$542,684 (11.4)	$409,809 (22.9)	$20,111 (-18.9)	$6,930 (30.9)	$29,981 (1.9)	$475,034 (17.1)	$3,072 (-20.7)	$478,106 (16.
RELIGIOUS ORGANIZATIONS	$11,838 (2.3)	$16,142 (10.9)	$76,332 (4.2)	$18,838 (26.5)	$140,389 (8.2)	$4,354 (23.7)	$144,743 (8.4)	$335 (-63.4)	$65 (-19.4)	$10 (-70.0)	$31 (-17.6)	$441 (-62.2)	$16 (-12.7)	$461 (-61.
OTHER SOURCES	$106,933 (16.7)	$20,489 (27.2)	$43,332 (3.8)	$7,679 (8.4)	$170,393 (13.8)	$443 (-49.4)	$170,836 (13.4)	$136,936 (-0.3)	$6,984 (1.5)	$2,708 (-19.5)	$11,902 (-1.1)	$158,530 (-0.7)	$623 (-37.5)	$160,573 (-0.8)
PURPOSES														
CURRENT OPERATIONS - UNRESTRICTED	$224,867 (-5.1)	$137,838 (5.8)	$287,766 (-2.7)	$42,298 (3.3)	$692,738 (-1.9)	$8,518 (1.8)	$701,256 (-1.8)	$86,922 (-17.5)	$16,768 (8.8)	$4,391 (66.0)	$6,072 (-25.3)	$115,093 (-13.4)	$1,607 (115.8)	$116,7 (-12.6)
CURRENT OPERATIONS - RESTRICTED	$678,116 (22.4)	$88,295 (29.7)	$119,982 (16.8)	$43,741 (7.6)	$926,144 (21.6)	$2,188 (56.4)	$928,332 (21.7)	$690,434 (14.6)	$57,303 (13.7)	$9,207 (19.1)	$64,906 (-3.4)	$821,951 (12.9)	$3,272 (18.7)	$825,2 (12.9)
CAPITAL PURPOSES	$689,396 (9.6)	$252,839 (11.3)	$418,944 (6.2)	$63,339 (-6.6)	$1,423,916 (7.6)	$8,134 (8.7)	$1,432,050 (7.6)	$393,368 (17.6)	$26,420 (-11.1)	$8,467 (19.3)	$39,371 (24.6)	$467,630 (15.5)	$3,077 (-18.6)	$471,3 (15.
GRAND TOTAL	$1,592,358 (12.3)	$478,162 (12.5)	$822,790 (2.8)	$149,378 (1.6)	$3,042,798 (9.8)	$18,840 (5.4)	$3,061,638 (9.8)	$1,170,725 (12.3)	$100,491 (-3.6)	$22,065 (26.3)	$111,352 (2.9)	$1,404,633 (10.4)	$8,047 (6.5)	$1,413,6 (10.

Table C VOLUNTARY SUPPORT RECEIVED IN 1983-84, ALL INDEPENDENT SECONDARY AND ELEMENTARY SCHOOLS REPORTING

(Including percentage of Grand Total in parentheses; dollars in thousands)

	DAY ELEMENTARY	DAY ELEMENTARY/ SECONDARY	DAY SECONDARY	DAY/ BOARDING	BOARDING & BOARDING/ DAY	TOTAL INDEPENDENT SCHOOLS
NUMBER OF INSTITUTIONS	43	169	54	49	116	431
GRAND TOTAL OF SUPPORT	$12,445 (100.0)	$96,402 (100.0)	$22,716 (100.0)	$31,676 (100.0)	$116,881 (100.0)	$280,119 (100.0)
PURPOSES OF SUPPORT						
CURRENT OPERATIONS - UNRESTRICTED	$6,123 (49.2)	$32,616 (33.8)	$10,153 (44.7)	$11,048 (34.9)	$34,642 (29.6)	$94,601 (33.8)
CURRENT OPERATIONS - RESTRICTED	$1,536 (12.3)	$8,640 (9.0)	$1,695 (7.5)	$2,701 (8.7)	$9,001 (7.7)	$23,633 (8.4)
CAPITAL - PROPERTY, BUILDINGS & EQUIPMENT	$3,090 (24.8)	$27,109 (28.1)	$4,793 (21.1)	$7,577 (23.9)	$25,780 (22.1)	$68,309 (24.4)
ENDOWMENT - INCOME UNRESTRICTED	$1,170 (9.4)	$14,946 (15.5)	$3,662 (16.1)	$5,110 (16.2)	$21,967 (18.8)	$46,855 (16.7)
ENDOWMENT - INCOME RESTRICTED	$561 (4.5)	$12,805 (13.3)	$2,364 (10.4)	$4,685 (14.8)	$24,169 (20.7)	$44,583 (15.9)
LOAN FUNDS	$5 (0.0)	$287 (0.3)	$49 (0.2)	$460 (1.5)	$1,343 (1.1)	$2,151 (0.8)
SOURCES OF SUPPORT						
ALUMNI/AE	$938 (7.5)	$26,026 (27.0)	$5,067 (22.3)	$11,486 (36.3)	$58,362 (49.9)	$101,858 (36.4)
PARENTS	$4,091 (32.9)	$28,886 (30.0)	$6,144 (27.0)	$9,002 (28.4)	$17,830 (15.3)	$67,663 (24.1)
OTHER INDIVIDUALS	$1,992 (16.0)	$17,238 (17.9)	$5,563 (24.5)	$4,774 (15.1)	$12,719 (10.9)	$42,278 (15.1)
FOUNDATIONS	$1,615 (13.0)	$14,676 (15.2)	$2,882 (12.7)	$4,442 (14.0)	$21,740 (18.6)	$45,355 (16.2)
CORPORATIONS & BUSINESSES	$431 (3.5)	$4,811 (5.0)	$1,037 (4.6)	$1,236 (3.9)	$4,135 (3.5)	$11,649 (4.2)
RELIGIOUS ORGANIZATIONS	$19 (0.2)	$289 (0.3)	$883 (3.9)	$307 (1.0)	$690 (0.6)	$2,187 (0.8)
OTHER ORGANIZATIONS	$869 (7.0)	$4,485 (4.7)	$1,140 (5.0)	$1,469 (4.6)	$1,406 (1.2)	$9,369 (3.3)
FORMS OF GIVING						
REALIZED BEQUESTS	$289 (2.3)	$5,182 (5.4)	$960 (4.2)	$1,136 (3.6)	$8,764 (7.5)	$16,330 (5.8)
TRUSTS, POOLED INCOME FUNDS & ANNUITIES	$211 (1.7)	$956 (1.0)	$73 (0.3)	$156 (0.5)	$1,207 (1.0)	$2,603 (0.9)
THE ANNUAL FUND						
TOTAL ALUMNI/AE OF RECORD	46,953	336,064	167,687	149,636	602,996	1,103,306
NUMBER SOLICITED	36,738	313,228	130,582	129,538	361,734	971,820
NUMBER OF DONORS	6,596	87,766	36,848	33,096	119,064	283,346
ALUMNI/AE GIFTS	$536	$9,047	$2,047	$3,968	$20,241	$36,600
TOTAL GIFTS	$5,040	$32,810	$9,991	$11,053	$37,695	$96,032
GIFTS OF PROPERTY						
COMPANY PRODUCTS	$830	$196	$36	$116	$296	$1,471
OTHER PROPERTY FROM CORPS.	$7	$81	$20	$27	$432	$566
OTHER PROPERTY FROM OTHER	$94	$835	$313	$861	$1,817	$3,361
CORP. MATCHING GIFTS						
NUMBER OF GIFTS MATCHED	424	4,011	933	1,327	5,105	11,800
AMOUNT MATCHED	$172	$1,452	$340	$373	$1,872	$4,227
VITAL STATISTICS						
EDUCATION & GENL. EXPEND.	$34,202	$313,270	$82,521	$126,289	$338,039	$1,114,405
NO. INSTIT. REPORTING	42	151	43	40	105	381
ENDOWMENT	$46,476	$464,694	$77,880	$150,759	$939,506	$1,677,215
NO. INSTIT. REPORTING	36	158	43	45	111	411

Table D VOLUNTARY SUPPORT RECEIVED IN 1983-84 BY INDEPENDENT SCHOOLS IN TWO SURVEY YEARS, BY SOURCE AND BY PURPOSE

(Figures in parentheses are percentage changes in 1983-84 as compared to 1982-83; dollars in thousands)

	DAY ELEMENTARY	DAY ELEMENTARY/ SECONDARY	DAY SECONDARY	DAY/ BOARDING	BOARDING & BOARDING/ DAY	TOTAL INDEPENDENT SCHOOLS
NUMBER OF INSTITUTIONS	37	149	42	42	101	371
SOURCES OF SUPPORT						
ALUMNI/AE	$798 (18.2)	$26,678 (34.7)	$2,980 (9.9)	$9,321 (8.0)	$57,368 (5.9)	$96,826 (12.6)
OTHER INDIVIDUALS	$5,761 (-22.5)	$43,663 (4.9)	$8,552 (30.6)	$10,432 (-3.4)	$27,350 (24.6)	$95,538 (8.3)
FOUNDATIONS	$1,137 (9.7)	$14,063 (5.2)	$2,613 (-16.6)	$3,506 (-22.4)	$20,560 (-1.5)	$41,636 (-2.4)
CORPORATIONS	$214 (-16.0)	$4,010 (1.5)	$769 (-3.5)	$1,083 (-20.5)	$3,393 (-5.2)	$10,067 (-5.8)
RELIGIOUS ORGANIZATIONS	$19 (101.6)	$241 (-5.1)	$744 (38.9)	$306 (-56.9)	$513 (-26.0)	$1,829 (-16.1)
OTHER SOURCES	$811 (2.2)	$4,041 (-1.0)	$953 (-19.5)	$1,162 (23.3)	$1,302 (-19.9)	$8,367 (-6.7)
PURPOSES						
CURRENT OPERATIONS - UNRESTRICTED	$3,962 (17.2)	$30,599 (16.0)	$7,053 (25.6)	$9,006 (12.1)	$32,033 (16.5)	$82,652 (16.1)
CURRENT OPERATIONS - RESTRICTED	$1,207 (-1.5)	$7,622 (-3.3)	$1,574 (33.0)	$2,451 (13.3)	$8,605 (15.1)	$21,459 (7.7)
CAPITAL PURPOSES	$3,571 (-30.2)	$52,835 (11.3)	$7,781 (-1.2)	$13,550 (-16.2)	$69,587 (2.8)	$147,325 (1.7)
GRAND TOTAL	$8,740 (-14.6)	$91,056 (11.0)	$16,408 (11.8)	$25,006 (-4.7)	$110,226 (7.6)	$252,236 (6.0)

Table E VOLUNTARY SUPPORT OF HIGHER EDUCATION, BY SOURCE AND BY PURPOSE

(Including percentage of Grand Total in parentheses; dollar totals in thousands)

	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84
NUMBER OF INSTITUTIONS	986	991	1,366	1,065	972	1,019	925	1,101	1,137	1,118
SOURCES										
ALUMNI/AE	$377,376 (22.5%)	$461,091 (24.4%)	$514,283 (24.1%)	$552,621 (23.6%)	$620,367 (24.3%)	$725,361 (23.7%)	$821,135 (24.8%)	$1,051,897 ** (25.7%)	$1,046,933 (24.0%)	$1,089,575 (23.3%)
NON-ALUMNI INDIVIDUALS	$399,814 (23.9%)	$447,065 (23.6%)	$557,621 (26.2%)	$588,914 (25.1%)	$582,169 (22.8%)	$677,997 (22.2%)	$790,096 (23.8%)	$916,511 (22.4%)	$1,007,200 (23.1%)	$1,096,443 (23.4%)
FOUNDATIONS	$384,980 (23.0%)	$431,016 (22.8%)	[illegible] [illegible]	$480,880 (20.5%)	$553,803 (21.7%)	$739,759 * (24.2%)	$726,868 (21.9%)	$840,357 (20.6%)	$862,148 (19.7%)	$909,666 (19.4%)
BUSINESSES, CORPORATIONS	$275,985 (16.5%)	$297,012 (15.7%)	$357,438 (16.7%)	$392,315 (16.7%)	$438,678 (17.2%)	$555,756 (18.2%)	$611,734 (18.4%)	$823,001 ** (20.1%)	$941,557 (21.6%)	$1,060,440 (22.7%)
RELIGIOUS ORGANIZATIONS	$87,496 (5.2%)	$101,969 (5.4%)	$108,985 (5.1%)	$122,403 (5.2%)	$127,161 (5.0%)	$126,269 (4.1%)	$107,969 (3.3%)	$146,037 (3.6%)	$176,433 (4.0%)	$157,757 (3.4%)
FUND-RAISING CONSORTIA	$108,716 (6.5%)	$118,712 (6.3%)	$148,195 (6.9%)	$162,667 (6.9%)	[illegible] (7.0%)	$174,264 (5.7%)	$79,321 (2.4%)	$82,993 (2.1%)	$85,831 (2.0%)	$70,085 (1.5%)
OTHER SOURCES	$40,343 (2.4%)	$33,967 (1.8%)	$46,615 (2.2%)	$67,125 (2.8%)	$53,826 (2.1%)	$57,689 (1.9%)	$182,941 (5.5%)	$225,408 (5.5%)	$248,069 (5.7%)	$296,169 (6.3%)
PURPOSES										
CURRENT OPERATIONS	$1,019,741 (60.9%)	$1,113,204 (58.9%)	$1,245,612 (58.2%)	[illegible] (57.5%)	$1,512,699 (59.2%)	$1,703,391 (55.8%)	$1,915,158 (57.7%)	$2,286,898 (56.0%)	$2,524,446 (57.8%)	$2,706,589 (57.9%)
CAPITAL PURPOSES	$654,802 (39.1%)	$777,628 (41.1%)	$893,015 (41.8%)	$998,616 (42.5%)	$1,043,296 (40.8%)	$1,351,662 (44.2%)	$1,402,906 (42.3%)	$1,799,306 (44.0%)	$1,843,725 (42.2%)	$1,971,546 (42.1%)
GRAND TOTAL	$1,674,543	$1,890,832	$2,138,627	$2,347,923	$2,555,995	$3,055,053	$3,318,064	$4,086,204	$4,368,171	$4,678,135

*Includes $105 million nonrecurring transfer.

**Includes $115 million in bequests from alumni and $30.4 million gift-in-kind from corporations for "other" purposes.

Table F ESTIMATED TOTAL VOLUNTARY SUPPORT OF HIGHER EDUCATION, BY MAJOR PURPOSE AND TYPE OF DONOR, 1949-50 TO 1983-84

(Millions of dollars)

YEAR	TOTAL VOLUNTARY SUPPORT	CURRENT OPERATIONS	CAPITAL PURPOSES	INDIVIDUALS ALUMNI	INDIVIDUALS NON-ALUMNI	FOUNDATIONS	BUSINESSES, CORPORATIONS	RELIGIOUS ORGANIZATIONS	OTHER
1949-50	$ 240	$ 101	$ 139	$ 60	$ 60	$ 60	$ 28	$ 16	$ 16
1950-51	260	107	153	64	64	62	30	19	21
1951-52	297	129	168	72	72	72	40	20	21
1952-53	350	161	189	85	85	85	50	22	23
1953-54	394	184	210	90	90	90	60	34	30
1954-55	475	200	275	111	118	85	63	43	55
1955-56	575	235	340	118	142	120	75	57	63
1956-57	840 *	260	580 *	120	159	344 *	87	63	65
1957-58	715	325	390	160	180	135	90	75	75
1958-59	760	417	343	186	186	107	119	78	84
1959-60	815	385	430	191	196	163	130	80	57
1960-61	900	400	500	196	202	219	147	82	54
1961-62	950	415	535	220	210	230	154	82	54
1962-63	1,050	505	545	254	227	246	169	92	62
1963-64	1,215	549	666	263	286	320	181	97	66
1964-65	1,400	610	790	288	340	402	196	101	73
1965-66	1,440	675	765	310	350	357	230	108	85
1966-67	1,480	710	770	324	373	337	249	107	90
1967-68	1,600	800	800	339	438	374	250	110	91
1968-69	1,800	870	930	434	452	434	272	100	108
1969-70	1,780	960	820	381	461	434	269	102	133
1970-71	1,860	1,050	810	450	495	418	259	104	120
1971-72	2,020	1,110	910	481	493	523	279	101	147
1972-73	2,240	1,230	1,010	530	600	524	320	99	167
1973-74	2,240	1,300	940	509	536	535	356	116	178
1974-75	2,160	1,370	790	486	516	497	357	112	192
1975-76	2,410	1,480	930	588	569	549	379	130	195
1976-77	2,670	1,620	1,050	638	646	558	446	136	246
1977-78	3,040	1,825	1,215	714	766	623	508	158	271
1978-79	3,230	2,010	1,220	785	736	701	556	161	291
1979-80	3,800 **	2,250	1,550 **	910	847	903 **	696	155	289
1980-81	4,230	2,590	1,640	1,049	1,007	922	778	148	326
1981-82	4,860 ***	2,870 ***	1,990 ***	1,280 ***	1,097	1,003	976 ***	175	329
1982-83	5,160	3,125	2,035	1,237	1,190	1,018	1,112	206	397
1983-84	5,600	3,405	2,195	1,305	1,316	1,081	1,271	190	437

*Includes approximately $257 million of faculty salary endowment grants.
**Includes $105 million nonrecurring transfer for unrestricted endowment.
***Includes $115 million in bequests from alumni for capital purposes and $30.4 million gift-in-kind from corporations for current operations.

APPENDIX 2

THE DEPARTMENT OF DEFENSE
REPORT ON

SELECTED UNIVERSITY LABORATORY NEEDS IN SUPPORT OF NATIONAL SECURITY

PREPARED FOR THE SUBCOMMITTEE ON
RESEARCH AND DEVELOPMENT OF
THE COMMITTEE ON ARMED SERVICES OF
THE UNITED STATES
HOUSE OF REPRESENTATIVES

29 APRIL 1985

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CHAPTER I

INTRODUCTION

A. RATIONALE

The Report of the House Armed Services Committee on the 1984 Department of Defense Authorization Act contained the following request: "Many of the university laboratories in which Department of Defense research programs are conducted are obsolete and in need of major modernization or replacement. The committee believes a study should be undertaken on the need to modernize university laboratories in the physical sciences, earth and ocean sciences, atmospheric sciences, engineering, computer sciences and other fields essential to our long-term national security. The survey should (1) document the laboratory needs of universities presently engaged in Department of Defense competitive research programs, (2) assess priorities by academic field, (3) provide estimates of costs to meet these needs, (4) provide specific recommendations appropriate to the Department of Defense and others designed to address the need, (5) state the consequences to our long-term national security."
This report is a response to that request.

The science and technology (S&T) base has, as its cornerstone, basic research which, in the U.S., tends to be concentrated at universities. Approximately two-thirds of basic research in science and engineering (S&E) is carried out in academia. There is a concomitant integration of basic research with graduate education. The nation reaps a double benefit from this model in that it concurrently generates both research results and future researchers. It is for this reason that the state of U. S. university laboratory facilities is so important to the nation's long-range economic and military competitiveness.

The evolution of science and technology tends to create a requirement for more sophisticated research facilities. Failure to keep pace with facilities' needs has a negative impact on researchers' creativity. This in turn limits the scope of scientific endeavor in the experimental disciplines. The consequences may include delays in the realization of new discoveries and a trend for faculty and graduate students to opt for theoretical studies rather than engage in experimental research with inadequate facilities. A further consequence is the difficulty of recruiting and retaining the most productive faculty in experimental disciplines.

The foregoing points work against university researchers undertaking experimental investigations. When researchers do so in spite of inadequate facilities, results of their endeavors can be compromised in a variety of ways. These include:

- Inadequate environmental control resulting in decreased quality of data

- Excessive down-time resulting in diminished productivity

- Outmoded equipment leading to imprecision in acquired data
- Crowded laboratory space resulting in diminished access to equipment for data gathering and maintenance purposes
- Contrived experimental set-ups representing safety hazards

B. DEFINITIONS

The following definitions will be used throughout this report:

Laboratory Needs-Facilities and equipment which collectively constitute vehicles for the generation of experimental data and other information. It denotes more than a stand-alone instrument (e.g., spectrometer, tensile tester, etc.) that can be operated in general laboratory space typically found on a university campus, but excludes general purpose laboratory buildings. Examples include wind tunnels, high voltage accelerator labs, clean rooms, wave tanks, etc., especially those housed within existing older buildings. It may also include specially designed structures required to house laboratory instrumentation and experimental facilities.

Facilities-Laboratory structural environment including hardware required to maintain special conditions in laboratory space.

Equipment-Instrumentation and devices directly supportive of data acquisition and analysis.

C. RESEARCH DISCIPLINES AND THRUST AREAS

Selected research laboratory needs among universities active in Department of Defense (DOD) competitive research programs are addressed in this report for the following five disciplines and constituent thrust areas:

CHEMISTRY
- Laser Chemistry
- Polymeric Materials

ELECTRONICS
- Microelectronic Fabrication and Reliability
- System Robustness and Survivability

ENGINEERING
- Combustion
- Composite Structures
- Energetic Materials
- Fluid Mechanics and Acoustics
- Manufacturing, Design, and Reliability
- Soil Mechanics

MATERIALS
- Optical and Magnetic Materials
- Silicon and Compound Semiconductor Growth
- Structural Ceramics
- Structural Composites

PHYSICS
- Astrophysics
- Coherent Radiation Sources
- Directed Energy Devices
- Optical Communications and Spectroscopy

The foregoing disciplines do not represent the breadth of DOD research. In particular, biological and biomedical sciences are not included in anticipation of a comprehensive survey of laboratory needs by the National Institutes of Health. Computer resources not dedicated to experimental research facilities are also excluded on the basis that they are the object of considerable study and/or aggressive enhancement programs by the National Science Foundation and the Department of Energy.

D. INFORMATION ACQUISITION

Requisite information was initially assembled by research administrators in the three Service research offices (OXRs): the Office of Naval Research (ONR), Army Research Office (ARO), and the Air Force Office of Scientific Research (AFOSR) and in the Defense Advanced Research Projects Agency (DARPA). In particular, Division Directors in each organization representing the foregoing five research disciplines supplied data related to the sufficiency of research laboratory facilities. This information was analyzed for the purpose of developing laboratory needs representative of defense research priorities. Results are presented in Chapter IV in the form of prioritized laboratory needs (where they exist), estimated costs of desired enhancements, and assessments of the scientific/technological and national security implications of any laboratory needs identified.

Within the framework of the foregoing information acquisition plan, each of the three OXRs identified key R&D performers for the various research disciplines. These performers were then analyzed with reference to the indicated questions. Criteria used in determining the performers to be interrogated and/or analyzed for inclusion in the report involved level of basic (6.1) competitive research funding, evaluations by OXR research administrators, and, as appropriate, independent evaluations of graduate programs corresponding to the various disciplines. In many cases, the stated costs represent partial funding reflecting the tendency of universities to seek multiple sponsors for major laboratory improvements. While the method of data collection does not embody the statistical integrity of a rigorously implemented survey instrument, it is nonetheless thought to be suggestive of the dimensions of university laboratory needs of greatest importance to DOD. Further, the study differs from previous ones in that the cited laboratory needs reflect, in part, the judgment of research sponsors (DOD scientific officers) rather than exclusively the perceptions of research performers.

The primary DOD research performers encompassed by this report are, of course, only a subset of the total university R&D community. The extent to which their modernization and new facilities needs may be extrapolated to all universities performing research for DOD, or to the entire population of approximately 300 research universities in the U.S., is an open issue. Such extrapolations beg the question, however, as to appropriate means for assessing laboratory sufficiency from the DOD perspective. This is a complex question that is under constant scrutiny for each discipline and its constituent research areas. More generally, it is an issue which demands continued vigilance at the national level. Sustained deficiencies in any discipline/thrust area will inevitably cause the corresponding sector of the U.S. science and technology base to erode, thus blunting our competitive position in the national security and world economic arenas.

CHAPTER II
DOD SUPPORT FOR UNIVERSITY LABORATORIES

A. INTRODUCTION

This chapter deals with the role that universities play in sustaining and strengthening the U.S. science and technology base (Section A), the origins of DOD support of university laboratories in that role (Section B), DOD programs that support university science laboratories (Section C.1), and further steps that DOD has taken to upgrade these facilities (Section C.2). A new university research initiative for FY 86 (Section C.3) and coordination activities relevant to the upgrading of university research facilities are described (Section C.4).

Given the importance of university science laboratories to DOD, it is also true that maintaining adequate university research facilities is a national priority that has important economic as well as military significance. Thus, DOD should not and cannot solve the problem alone. Solutions must encompass all relevant government agencies, private industry, and, of course, the universities themselves. This chapter focuses, however, on the relationship between DOD and the university community.

American universities play an indispensable role in maintaining and strengthening the nation's science and technology base. Not only are universities the source of future scientists and engineers, but the research contributions of academia to society are vast as well. Since World War II, universities have performed most of the basic research that has produced the technological innovations on which much of our economy and national defense are based today. Universities contribute nearly three-quarters of the scholarly papers published in the most noted science and technology journals. In addition to generating the insight and knowledge upon which future technological innovation is based, university research provides the environment for the development of future scientists and engineers. The result is enrichment of the professional experience of faculty and graduate students involved in training our nation's technical manpower. Thus, support of university research produces multiple benefits of enormous value to society as a whole.

This report addresses selected needs of university laboratories involved in DOD sponsored research. As much as $2 billion has been estimated as the total sum needed to replace obsolete university research instrumentation. Laboratory facilities, including the instrumentation required to conduct research aimed at modernizing and expanding the U.S. technology base, are becoming increasingly expensive. Establishing and maintaining such facilities are very costly, especially those requiring advanced supercomputers, large particle accelerators, various types of analytical instrumentation, imaging devices, and automated design and manufacturing hardware. Nonetheless, such equipment is crucial for the conduct of research in important areas of science and engineering, and for educating students. DOD support for university research equipment is described in the following sections.

B. ORIGINS OF DOD SUPPORT FOR UNIVERSITY LABORATORIES

The DOD has recognized that technological superiority is essential to military superiority, and it has played an important role in maintaining the strength of the U.S. science and technology base. Since DOD was among the first federal agencies to recognize the essential role that the academic community plays in the maintenance of U.S. technological leadership, it has maintained a strong relationship with U.S. universities since before World War II.

Very little involvement of universities with military technology occurred during World War I, despite the existence of in-house Service laboratories since the 1890s and the earlier creation of the National Academy of Sciences, which was established as a war measure by President Lincoln in 1863. The sudden expansion of experimental and laboratory operations that characterized the outbreak of World War II greatly overburdened the Service laboratories. Many civilian scientists and engineers were added to the staffs of Aberdeen Proving Grounds, the Naval Research Laboratory, the Naval Ordinance Laboratory, Taylor Model Basin, Wright Field (Army Air Force), and Fort Monmouth (Signal Corps). Contracting funds were also greatly increased in the effort to catch up to an enemy that had scientific groups investigating improved weaponry since the early 1920s.

The Office of Scientific Research and Development (OSRD) was created, reporting directly to President Roosevelt, and receiving funds by direct appropriation from the Congress. These funds were placed in private and governmental laboratories. The National Research Council of the National Academy of Sciences had been created during World War I and was, by the time of World War II, well known to the military Services, which expanded their use of it. These arrangements formed a close coupling of the organized bodies of scientists and military leaders having a common appreciation of the importance of science and engineering to modern warfare. Major wartime expansion of facilities occurred at several universities. The major contributors included MIT, Harvard, Columbia, the University of Chicago, the University of California, the Johns Hopkins University, and the California Institute of Technology. Radar, acoustics, operations research, navigation, and atomic weapons were just a few of the areas in which notable contributions were made.

Emerging from the wartime era were two lasting methodologies for defense investment in university laboratory facilities. First, the institute concept became well established, wherein non-profit university affiliated laboratories conduct applied research, primarily under DOD support. Products of this era which make major contributions today are Lincoln Laboratories (MIT), the Johns Hopkins University Applied Physics Laboratory, the Applied Physics Laboratory of the University of Washington, the Applied Research Laboratories of the University of Texas, the Applied Research Laboratory of Pennsylvania State University, and the Marine Physical Laboratory, Scripps Institute of Oceanography, University of California, San Diego. Second, the National Security Act of 1947, and the amendment of 1948 which established the three military Departments and the Office of the Secretary of Defense, provided the framework that operates today for support of research at universities through the Army Research Office, the Office of Naval Research, the Air Force Office of

Scientific Research, and the Defense Advanced Research Projects Agency. This partnership has been substantial over the years; seventeen institutions of higher education are among the 595 contractors that received awards of 10 million dollars or more from DOD in FY 83.

C. PRESENT DOD SUPPORT FOR UNIVERSITY LABORATORIES

C.1 DIRECT FUNDING OF UNIVERSITY RESEARCH

U.S. universities are a major factor in current DOD activities affecting the U.S. technology base. Approximately half of all DOD basic research (6.1) funds are expended at universities ($405 million in contract dollars with research budgets totaling $840 million in FY 84), plus a smaller amount of applied research (6.2) funds (approximately $115 million in FY 84). During the past decade, DOD has made a major effort to reverse the effects of the relative neglect of university research that occurred during the Vietnam war. Figure II-1 shows the evolution of DOD funding for basic research (6.1) since 1962. The corresponding funding history for "exploratory development" (6.2), some of which equates to applied research, is shown in Figure II-2.

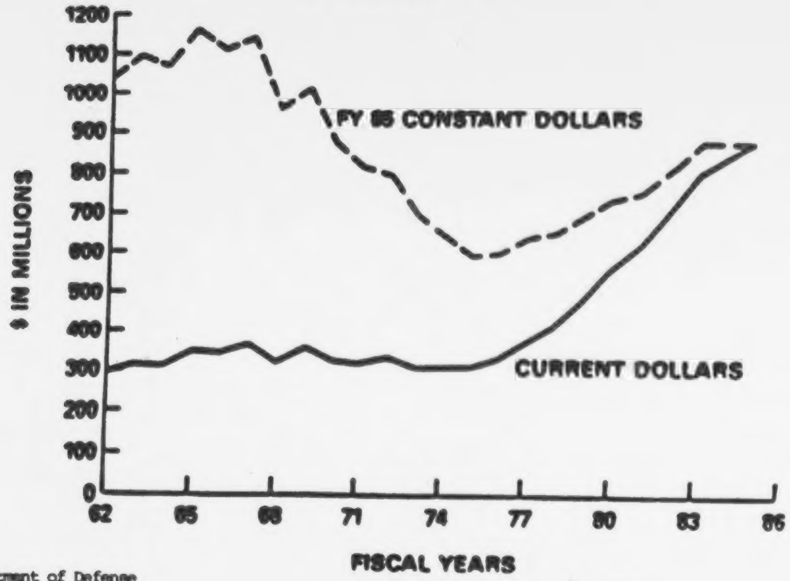
These figures show that funding in current dollars for both components of the technology base grew significantly during the late 1970s and early 1980s; nevertheless, neither has returned to 1965 levels of support in constant dollars. In fact, in real terms, the level of funding for exploratory development has been virtually stable for over a decade. In a memorandum to the Services dated August 9, 1984, Secretary Weinberger noted this situation and indicated that the Defense Guidance for the FY 1987-91 POM would request 8 percent annual real growth in both components of the technology base. DOD still takes that position.

University research has been a major component of the growth in DOD technology base activities during the past decade. Table II-1 shows DOD Basic Research (6.1) funds spent (or projected to be spent) at universities by the Army, Navy, Air Force, and the Defense Advanced Research Projects Agency (DARPA) for the years FY 74-86. During the period FY 75 to FY 84, DOD spending for 6.1 Basic Research at universities grew at a real annual rate of 9 percent--far higher than the annual growth of DOD Research (6.1) funds as a whole.

Table II-1 shows only the DOD Basic Research (6.1) funds going to universities. It includes only contracts exceeding $25,000, and does not reflect research grants. Thus total university funding is somewhat higher than indicated. A similar break-out of the university component of DOD Exploratory Development (6.2) funds is not available. To provide a basis for comparing 6.1 and 6.2 expenditures, in FY 83 a total of $102.3 million in DOD Exploratory Development (6.2) contracts went to universities while $360 million was provided for Research (6.1) contracts. An additional $50 million was awarded to universities in the form of 6.1 research grants. DOD funding for universities is not limited to Research and Exploratory Development. For example, DOD RDT&E (6.1 through 6.6) contracts over $25,000 going to educational institutions in FY 83 totaled $1113.6 million. Most of the $600 million in the higher categories (6.3, 6.4, 6.5, and 6.6) was for R&D in university affiliated off-campus laboratories and Federally Funded Research and Development Centers (FFRDCs), or for vocational and technical training, and tuition fees.

DOD SCIENCE AND TECHNOLOGY FUNDING TRENDS

CURRENT AND CONSTANT DOLLARS
RESEARCH (6.1)

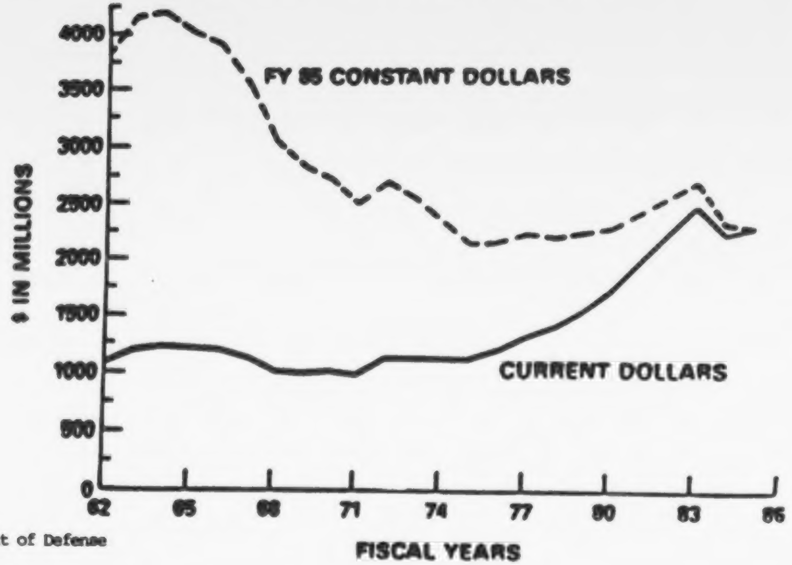


SOURCE: Department of Defense

FIGURE II-1

DOD SCIENCE AND TECHNOLOGY FUNDING TRENDS

CURRENT AND CONSTANT DOLLARS
EXPLORATORY DEVELOPMENT (6.2)



SOURCE: Department of Defense

FIGURE II-2

TABLE II-1

DEPARTMENT OF DEFENSE FUNDING FOR UNIVERSITY BASIC (6.1) CONTRACT RESEARCH, FISCAL YEARS 1974-85[+]

(In millions of dollars)

	FY 74		FY 75		FY 76		FY 77		FY 78		FY 79		FY 80	
Service	Current	Real	Current	Real	Current	Real	Current	Real	Current	Real	Current	Real	Current	[illegible]
ARMY	13.7	27.9	13.4	25.0	19.0	33.7	23.7	39.6	28.1	43.8	32.0	45.9	39.1	[illegible]
AIR FORCE	23.2	47.3	22.9	42.6	28.2	50.0	41.0	68.6	49.5	77.1	46.4	66.5	55.3	[illegible]
NAVY	45.5	92.7	47.0	89.2	64.2	113.8	62.7	104.8	70.8	110.3	86.4	124.0	109.2	[illegible]
DARPA	21.9	44.6	19.4	36.1	19.1	33.9	18.7	31.3	17.9	27.9	21.0	30.1	19.8	[illegible]
TOTAL	104.3	212.4	103.6	192.9	130.5	231.4	146.1	244.3	166.3	259.0	185.8	266.5	213.4	[illegible]

	FY 81		FY 82		FY 83		FY 84		FY 85*		FY 86*	
Service	Current	Real	Current	Real	Current	Real	Current	Real	Current	Real**	Current	Real**
ARMY	46.5	55.9	56.1	63.5	71.4	77.7	80.6	84.6	83.8	83.8	87.9	93.8
AIR FORCE	63.4	76.2	71.5	81.0	90.3	98.3	112.1	117.6	119.1	119.1	135.0	129.7
NAVY	115.0	138.2	142.3	161.2	152.2	165.6	158.1	165.9	176.1	176.1	190.8	189.5
DARPA	27.3	37.8	39.4	44.6	46.4	50.5	53.9	56.6	42.7	42.7	43.4	41.4
TOTAL	252.2	303.1	309.3	350.3	360.3	392.1	404.7	424.7	421.7+	421.7	459.1	437.7

---

* Projections

** Forecast for inflation is based on CBO projection

SOURCE: Army Deputy Chief of Staff Research Development and Acquisition, Office of Naval Research, Air Force Office of Scientific Research, Defense Advanced Research Projects Agency, (Constant 1985 Dollars Calculated using GNP Implicit Price Deflator)

[+] Restricted to awards exceeding $25,000; grants are not included

DOD sponsors research and development at universities to ensure the progress in fundamental knowledge that is necessary, in the long run, to maintain U.S. technological superiority. The resulting university research programs also serve to benefit universities in a variety of ways. By providing opportunities to perform basic research at the forefront of science and engineering, research programs at universities help to create an environment that can attract and retain faculty and students. Past studies suggest that, on average, $1 million of funding for research provides full or partial financial support for 10-15 graduate students. Using this measure, DOD provided financial assistance for over 4000 graduate students through its university research programs in FY 84. In addition, as will be noted below, DOD-related research programs also have significant effects on laboratory instrumentation.

C.2 INSTRUMENTATION PROGRAM

Instrumentation is essential to modern research. Modern instruments with qualitatively superior capabilities for analysis and measurement often open new fields of scientific inquiry. In some scientific areas, access to the most advanced scientific instrumentation determines in large measure the extent to which scientists can work at the cutting edge of their field.

The Department of Defense, in concert with the scientific and university community, state and other federal agencies, and the Congress, perceived that the condition of research instrumentation in U.S. universities declined significantly during the 1970s. The Association of American Universities (AAU), in a report to the National Science Foundation (NSF) in June 1980 (see Chapter III), concluded that the equipment being used in the top ranked universities has a median age twice that of the instrumentation available to leading industrial research laboratories, an additional factor in the attraction of potential faculty to industry.

The instrumentation problem has been growing for more than a decade. It reflects both economic factors and funding patterns:

- The cost of equipment has risen much faster than inflation.
- The system of one to three year contracts in the $50,000 to $100,000 per year range with individual investigators is not conducive to obtaining equipment that costs more than $50,000.
- Rapid technological advances are rendering research equipment obsolete at an ever increasing rate.

In response to the foregoing situation, DOD has encouraged researchers to include more of their equipment needs in proposals and emphasized that DOD does not set arbitrary limits on the amount of money that may be requested for instrumentation. This approach has been helpful for equipment needs in the $50,000 range or less. However, new money was clearly needed for some of the more expensive items required to modernize university laboratories. These funds were provided in FY 83 through the DOD-University Research Instrumentation Program (URIP), which received Congressional approbation.

URIP provides $150 million over five years for university research equipment. Each of the three Services is programmed to spend $10 million per year. So far, $90 million has been spent on 652 awards going to 152 institutions in 47 states and Washington, D.C., Guam, and Puerto Rico. While URIP is having a major impact on the equipment needs of researchers doing work of interest to DOD, it cannot solve the whole university instrumentation problem. In the first year of URIP, DOD received 2,500 proposals representing requests for $646 million worth of equipment. While some of these requests were for equipment to support research in areas not usually funded by DOD, this response is a significant and impressive measure of the needs of the universities.

URIP is the most visible, but not the sole, DOD response to the university instrumentation problem. As noted previously, each of the Services and DARPA have encouraged current and prospective contractors to make their equipment needs known, in order that many of the less expensive items could be purchased as an integral part of research program funding:

- Approximately 10 percent of Army, Navy, and Air Force research contract funding is applied to equipment purchases, most of it well under $50,000. Grants under the URIP program provide an additional comparable dollar amount for equipment costing more than $50,000.
- The portion of the Army Research Office (ARO) contract program devoted to instrument purchases has increased steadily over the past decade; in FY 85, such purchases will represent about $6 million of the ARO contract research program.
- University-related equipment purchases associated with the Contract Research Program of the Office of Naval Research (ONR) increased from $11.2 million in 1979 to $16.6 million in 1984.
- Between 1975 and 1985, vested equipment funding by the Air Force Office of Scientific Research (AFOSR), during the usual course of its sponsored research program, increased from $2 million to $8 million.
- Although DARPA does not participate in the URIP program, 10 to 20 percent of its university program funds have been utilized for equipment. In 1981, DARPA began a modernization program focused on obsolete equipment and the need for greater computational power. From 1981 to 1984, equipment purchases by universities using DARPA funds increased from $6.7 million to $16.8 million.

In certain cases where the equipment for major research efforts has been especially costly, provisions have been made for extraordinary purchases. Examples include the purchase of large main frame computers, semiconductor processing lines, molecular beam epitaxy and analysis chambers, and ARPANET computational and communication facilities by DARPA, and an ongoing ONR program to refurbish selected research vessels.

In FY 84, in addition to the $30 million per year of special URIP purchases, the three Services and DARPA purchased over $45 million worth of research instruments and equipment for universities in connection with their research contracting activities.

C.3 UNIVERSITY RESEARCH INITIATIVE

In FY 86, DOD plans to establish new research program elements that will be focused exclusively on the DOD/university relationship. Total proposed funding for the new program elements is $25 million in FY 86 and $50 million in FY 87. Significant additional growth is expected after FY 87. Each of the Services and DARPA will implement programs within these program elements to meet the priorities of their own relationships with the academic community. Although the specific proportions will vary from Service to Service, graduate fellowships, support for young investigators, purchase of research instrumentation, support of special research programs, and programs to improve the interactions between DOD laboratory and university researchers, will be part of the total DOD package.

C.4 COORDINATION ACTIVITIES

DOD has long recognized that the academic community is an invaluable source of expert advice. The Department draws on science and engineering faculty as individual consultants and as members of DOD advisory committees. To insure more effective communication with the academic community, DOD established the DOD/University Forum in December 1983. During its first year, the Forum has provided a mechanism for dialogue between DOD and the academic community on policy and other issues of mutual interest. One significant outcome of its activities during the past year was the establishment of a new DOD policy on the transfer of scientific information. It establishes an appropriate balance between the conflicting imperatives of national security and open scientific communications. The Forum Working Group on Science and Engineering Education addressed many issues, including that of research instrumentation.

CHAPTER III

PREVIOUS STUDIES

More than a dozen studies of university laboratory facilities have been prepared since the late 1960s. For a comprehensive listing and summary of such studies prepared by Linda S. Wilson of the University of Illinois at Urbana-Champaign, see the Appendix. Many of these studies have concluded that a problem exists with respect to inadequate and deteriorating university laboratory research facilities. Some of the studies are qualitative and generally recommend programs for the support of facilities renewal. Others are quantitative and are based on surveys of the conditions of facilities, with projections of the amount and cost of construction and renovation required to meet future needs. The basic conclusion drawn is that renewal and replacement of facilities are an important element in assuring a national technology base. Some of the more relevant studies for the purposes of this report are discussed below. An analysis of some of their findings in comparison to the present study is given in Chapter V.

-- A report to the National Science Foundation (NSF) by the Association of American Universities (AAU) in June, 1980, was devoted to "The Scientific Instrumentation Needs of Research Universities." Numerical data for the study were gathered from 14 universities and four commercial laboratories. The report found that the median age of university equipment was twice that of the commercial laboratories' instrumentation. Concluding that "the quality of research instrumentation in major university laboratories" has seriously eroded, the AAU report recommended that:

> "Federal policy for the support of research instrumentation should provide for a basic three-part funding strategy:
>
> - Strengthen instrumentation funding in the project system.
> - Expand special instrumentation programs.
> - Create in the National Science Foundation a new, supplemental formula grant program to provide needed flexibility to meet diverse institutional needs."

-- A 1981 study prepared for the Committee on Science and Research of the AAU, entitled "The Nation's Deteriorating University Research Facilities," was based on a survey of recent expenditures and projected needs of fifteen major U.S. universities in six disciplines. The principal findings of the study were:

- A substantial backlog of research facilities and equipment needs was accumulating.
- During the 1978-81 period, for the six fields surveyed, the fifteen universities spent $400 million for facilities and major equipment. In the next three years (1982-84),

these universities expected to spend almost twice as much ($765 million), just to produce the necessary research facilities and special research equipment for current faculty only.

- New construction to replace outmoded facilities accounted for almost 60 percent of total projected funding requirements across all fields.
- In addition, substantial needs for major research equipment were identified in all six fields.

Table III-1 shows the expenditures and projected needs for those disciplines included in the present report. Projected needs for both facilities and equipment were far larger (by factors ranging from three to almost ten) than actual expenditures for an equivalent period immediately preceding the report. The extent to which these differences represented realistic assessments of the pent-up facilities demand, and/or an effort on the part of survey respondents to "make a statement," is open to question.

Among the recommendations of the AAU study was:

- Provided that a review by key government agencies corroborated the assessment of the survey, the "Department of Defense, Department of Energy, the National Aeronautics and Space Administration, the Department of Health and Human Services, and the Department of Agriculture should establish research instrumentation and facilities rehabilitation programs targeted on the fields of science and engineering of primary significance to their missions."

-- In 1982, Flad & Associates, a Wisconsin architectural and planning firm, published their "Capital Spending Study of Research and Development Laboratories." Since the study focused exclusively on the spending plans of private industrial firms, it provides a useful basis for comparison with the plans of universities dealt with in the AAU studies described above.

The Flad study was based on a survey of some 5800 directors of industrial research laboratories. About twelve percent of them responded with detailed, confidential estimates of planned spending for plant and equipment in the ensuing three years (1983-85). The firms surveyed were considered more representative of large research laboratories (25-100 staff) than smaller laboratories (less than 25).

Among the major findings of the Flad study were:

- Estimated spending on research and development plant for 1983-85 by responding firms was $1.4 billion.
- Estimated spending on research and development equipment for 1983-85 was $1.2 billion.
- Nearly 40 percent of the laboratories of responding firms were built less than ten years before the survey; of these, 50 percent had undergone additions or renovations subsequent to initial construction.

Table III-1

Actual and Projected Expenditures for Research Facilities
(new construction/renovation) and Special Research Equipment
for 15 Major Research Universities
(thousands of dollars)

	FACILITIES			SPECIAL RESEARCH EQUIPMENT		
			PROJECTED NEEDS			PROJECTED NEEDS
FIELD	1978-80	1981	1982-84	1978-80	1981	1982-84
Chemical Sciences	13,835	14,089	115,022	6,701	4,767	14,688
Engineering	19,539	18,476	183,106	16,101	10,957	33,222
Physics	11,700	5,818	74,725	4,603	1,092	22,590

Source: "The Nation's Deteriorating University Research Facilities", Association of American Universities, 1981

For the purposes of this report, the Flad study has some interesting implications. If the study's findings are extrapolated onto the entire sample, total national private industry projected capital spending for research and development would be about $20 billion for 1983-85 (about $11 billion for plant and about $9.2 billion for equipment). This compares with estimates of $1 billion for total average annual planned investments in university science and education facilities. For industrial laboratories whose annual research and development budgets were in the range of 1 to 15 million dollars (45 percent of the responding firms), the expenditure planned for was about 13 percent of their annual operating budget each year for the three years beginning in 1983. The ratio of planned expenditures for equipment and plant by private industry was about the same (unity) as that shown for universities in Chapter IV below.

-- The NSF published a study of "Academic Research Equipment in the Physical and Computer Sciences and Engineering" in December 1984. This study surveyed 43 universities; respondents exhibited serious concern about the adequacy of their current stock of research equipment. Among the findings of the study were:

o About half of the department heads in physical and computer sciences and engineering characterized research instrumentation available to untenured and tenured faculty as "insufficient."

o 90 percent of the department heads surveyed reported that, as a result of lack of needed equipment, their research personnel could not conduct critical experiments in important subject areas.

o The top priority need was to upgrade and expand research equipment in the $10,000 to $1,000,000 range.

o The estimated original purchase cost of the entire 1982 stock of all $10,000 to $1,000,000 academic research equipment that had been accumulated in the fields surveyed was about $1 billion.

o Only 16 percent of those systems were classified as state-of-the-art. Of the equipment that was not in the state-of-the-art category, over half was in less than excellent condition; about half of such equipment was the most advanced to which researchers had access.

In addition to the studies and data surveyed above, the NSF has released a variety of data that are of special interest for this report. Table III-2 gives seven-year trend data on capital expenditures at all U.S. universities for both research and instructional purposes. Unfortunately, there does not appear to be any systematic way of extracting purely research facility expenditures from these figures. The two research categories cited correspond roughly to the five disciplines addressed in this report.

TABLE III-2

Research and Instructional Capital Expenditures at Colleges and Universities*

(thousands of dollars)

FIELD	1976	1977	1979	1980	1981	1982	1983
Engineering	81,678	87,718	87,128	89,297	103,329	144,990	134,701
Physical Sciences	73,755	65,216	64,685	77,154	87,813	82,362	87,073
Total:	155,433	152,934	151,813	166,451	191,142	227,352	221,774

Source: National Science Foundation

* 1978 Data not available.

Research equipment expenditures for U.S. colleges and universities are summarized in Table III-3 for 1982 and 1983. The data were obtained from 85 percent of U.S. universities in response to an NSF questionnaire concerning non-capitalized equipment expenditures. Engineering equipment purchases averaged approximately $70 million for the two year period. The category compares roughly to the combined engineering, electronics, and materials categories of this report.

Table III-4 lists 1982 estimated research equipment expenditures for 157 of the largest research universities. These 157 institutions collectively accounted for 95 percent of all nonmedical, non-FFRDC R&D expenditures reported to NSF for FY 1980 by all U.S. colleges and universities. Thus, although the survey represented only a small fraction of the nation's approximately 3,000 post-secondary institutions, it encompassed most institutions with significant capabilities for the kinds of advanced research that require instrumentation in the $10,000+ range. The quoted figures are somewhat higher than those in Table III-3, since they include capitalized equipment, whereas the data of Table III-3 do not. As in Table III-3, the engineering category compares roughly to the combined engineering, electronics, and materials categories of this report.

Acquisition and replacement costs as of 1982 for research equipment in the physical sciences and engineering are given in Table III-5. The total replacement value in 1982 dollars for both fields exceeded $1 billion. It is interesting to note that equipment maintenance in both the physical sciences and engineering represented 5 percent of replacement costs.

TABLE III-3

Annual Expenditures for Research Equipment
at Colleges and Universities
(thousands of dollars)

FIELD	1982	1983
Engineering	65,861	75,171
Aero/Astro	2,284	2,837
Chemical	6,442	6,172
Civil	5,164	6,086
Electrical	18,454	20,685
Mechanical	7,390	10,008
Other	26,127	29,383
Chemistry	33,323	32,826
Physics and Astronomy	38,316	39,916
Totals:	111,373	118,530

Source: National Science Foundation

TABLE III-4

Instrumentation-related expenditures in academic departments and facilities, by field and type of university: National estimates, FY 1982[1]

[Dollars in millions]

Principal field of research in department/facility and type of university	FY 1982 expenditures			
	Total	Purchase of research equipment[2]	Purchase of research-related computer services[3]	Maintenance/ repair of research equipment[4]
Total, selected fields	$375.6	$231.0	$84.7	$60.0
Field of research				
Physical sciences, total	156.6	94.5	33.9	28.2
Chemistry	73.7	39.6	23.3	10.8
Physics and astronomy	83.7	55.2	10.9	17.6
Engineering, total	154.4	90.9	43.9	19.6
Electrical	52.9	36.2	11.5	5.2
Mechanical	23.0	8.7	10.8	3.5
Metallurgical/materials	9.4	7.4	0.8	1.2
Chemical	15.8	7.8	5.7	2.3
Civil	16.4	9.6	5.4	1.4
Other, n.e.c.	36.7	21.3	9.5	5.9

[1] Statistical estimates encompass all research departments and all nondepartmental research facilities in the physical sciences, engineering and computer science at the 157 largest R&D universities in the U.S., except: (a) departments with no research instrument systems costing $10,000 or more and (b) research installations consisting of interrelated components costing over $1 million (large observatories, reactors, accelerators, etc.). Sample size = 353 departments facilities. The columns below do not add up to the indicated totals because computer science and interdisciplinary have been omitted from this abbreviated version of the original table.

[2] Estimates refer to expenditures for nonexpendable, tangible property or software having a useful life of more than two years and an acquisition cost of $500 or more, used wholly or in part for scientific research.

[3] Estimates refer to purchase of computer services at on-campus and off-campus facilities but not to purchase of computer hardware or software.

[4] Estimates encompass expenditures for service contracts, field service, salaries of maintenance/repair personnel, and other direct costs of supplies, equipment and facilities for servicing of research instruments.

Source: "Academic Research Equipment in the Physical and Computer Sciences and Engineering"; National Science Foundation, December, 1984.

TABLE III-5

Number and aggregate cost/value of academic research instrument systems in active research use, by field and type of university: National estimates, 1982.[1]

[Dollars in millions]

Principal field of research use and type of university	Number of systems	Index of aggregate cost/value			
		Purchase cost[2]	Acquisition cost[3]	Replacement value[4]	1982 cost-equivalent[5]
Total, selected fields	17,586	$758.1	$703.2	$1,133.7	$1,162.8
Field of research					
Physical sciences, total	8,424	373.6	353.2	529.3	610.2
Chemistry	4,791	210.4	201.1	295.0	331.7
Physics and astronomy	3,633	163.2	152.1	234.3	278.4
Engineering, total	6,829	259.4	232.4	413.3	374.6
Electrical	1,650	66.4	56.0	92.2	89.0
Mechanical	1,363	50.9	47.8	95.5	66.9
Metallurgical/materials	998	39.0	36.6	65.2	60.9
Chemical	682	23.3	22.8	28.6	32.3
Civil	397	14.1	13.9	22.4	21.6
Other, n.e.c.	1,739	65.7	55.3	109.0	104.0

[1] Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems. The columns below do not add up to the indicated total because computer science, materials science, and interdisciplinary have been omitted from this abbreviated version of the original table.

[2] Manufacturer's list price at time of original purchase.

[3] Actual cost to acquire instrument system at this university, including transportation and construction/labor costs.

[4] User estimate of 1982 cost of same or functionally equivalent equipment.

[5] Original purchase cost converted to 1982 dollars using Machinery and Equipment Index of the Bureau of Labor Statistics' Annual Producer Price Index to adjust for inflation.

Source: "Academic Research Equipment in the Physical and Computer Sciences and Engineering"; National Science Foundation, December, 1984.

CHAPTER IV

SELECTIVE UNIVERSITY LABORATORY MODERNIZATION

A. INTRODUCTION

This chapter addresses selected laboratory needs, i.e. facilities and related equipment, for a segment of the research university community representing key performers of DOD research for the disciplines and thrust areas enumerated in Chapter I. These needs, stratified by discipline and priority in Table IV-1, reflect the judgment of university research performers and, in certain cases, of administrators in the Service research offices (OXRs) and the Defense Advanced Research Projects Agency (DARPA). It should be emphasized that the cost figures in Table IV-1 are estimates of university laboratory upgrade and modernization initiatives designed to bring university laboratories closer to sufficiency from the DOD perspective. As previously indicated, they represent in many cases only partial funding of the facilities in question through multiple sponsor arrangements. They are not intended to encompass laboratory needs of the entire university research community. The latter issue has been addressed in the various studies cited in Chapter III. Facilities costs vary among and within disciplines, reflecting special requirements for the various thrust areas. They encompass both floor space requirements and laboratory accessories not falling within the instrumentation category. Thus, not all expenditures classified as "facilities" represent requirements for new or renovated buildings. The stated new floor space requirements are expressed in "gross" (as opposed to "net") square feet at \$120/ft^2. Laboratory renovation costs are calculated at \$90/ft^2.

The allocation of laboratory needs among the five disciplines required the exercise of judgment as to the appropriate division between (a) the parent, pure science fields of Physics and Chemistry, and (b) the applications-focused areas of Electronics, Engineering, and Materials. Ultimately, such decisions are to an extent arbitrary. Further, there are clearly a great number of ways to stratify facilities and equipment needs in terms of disciplines and thrust areas. The scheme presented in this report is thus only one of many possible approaches.

Priority 1 facilities needs for the five subject disciplines, pro-rated over a five-year expenditure period, are \$32 million per year. The expenditure level is equivalent to the URIP annual allocation of \$30 million. It is also of interest to note that priority 1 equipment requirements are \$31 million per year, i.e., almost identical to the annual expenditure rate of the five-year \$150 million URIP initiative. Unquestionably, some portion of the \$155 million Priority 1 equipment needs cited in this report will be addressed during the final two years (\$60 million) of the URIP program.

Table IV-1. Summary of selected laboratory needs of major university performers of defense research.

			Cost ($ thousands)*		
Discipline	Priority	Building Requirements (gross ft^2)	Facilities	Equipment	Total Costs
Chemistry	1	35,000	5,000	14,000	19,000
	2	412,000	44,700	33,400	78,100
Subtotals		447,000	49,700	47,400	97,100
Electronics	1	130,000	49,000	33,000	82,000
	2	25,000	6,000	8,000	14,000
Subtotals		155,000	55,000	41,000	96,000
Engineering	1	296,500	36,200	39,000	75,200
	2	45,300	8,900	18,300	27,200
Subtotals		341,800	45,100	57,300	102,400
Materials	1	220,000	55,000	62,100	117,100
	2	170,000	29,000	36,400	65,400
Subtotals		390,000	84,000	98,500	182,500
Physics	1	80,000	15,800	9,300	25,100
	2	131,000	25,700	163,300**	189,000**
Subtotals		211,000	41,500	172,600**	214,100**
Summary	1	761,500	161,000	157,400	318,400
	2	783,300	114,300	259,400**	373,700**
Totals		1,544,800	275,300	416,800**	692,100**

*Numbers are rounded to the nearest $100 thousand.

**Includes $150 million for astrophysics high angular resolution imager.

B. DISCIPLINES

B.1. Chemistry

Large facilities are playing an increasingly important role in chemical research. It has been an evolutionary process, starting with opportunities provided by large instrumentation and moving to facilities comprised of clusters of large integrated instrumentation/computational facilities in regional spectroscopic facilities.

Ultra high vacuum chambers with sophisticated analytical instrumentation using laser, electron, and ion cluster beams, together with various spectrometers, are mandatory for leading edge research in many areas of chemistry. Lasers have become important analytical tools to study the dynamics of chemical reactions and to photoinduce reactions. These instruments are usually short wavelength visible or ultraviolet tunable lasers that are themselves pushing the limits of laser technology and hence require considerable expertise and expense to operate and maintain. In addition, many research projects are concerned with the chemistry of materials processing, such as integrated circuit fabrication, that demand clean room facilities by their very nature.

In order to remain globally competitive, particularly in areas of chemistry of importance to DOD, it has been recently recognized that traditional chemical research laboratory facilities at universities are in serious need of upgrading and that shared centralized new facilities are necessary due to the high costs of the instrumentation and environmental control required. This evaluation applies to the two topical areas identified by DOD research managers as candidates for facilities upgrading, based on scientific opportunities and on laboratory needs. These priority topics are laser chemistry and polymeric materials.

Lasers have become a valuable tool in many branches of chemistry. Catalytic activity and selectivity can be studied by using laser Raman spectroscopy to determine the vibrational modes and polarization of structures of molecules adsorbed on single crystal surfaces. High powered photo-ionizing lasers can be used in conjunction with ion cyclotron resonance spectroscopy to study the role of metal ions as selective chemical ionization reagents. Laser induced fluorescence of metallic ions and subsequent transfer of energy to neutral ions may yield superior detection limits, compared to well established analytical techniques that employ fluorescence of neutral metal ions in flames. Two step laser photo dissociation of small molecules can be used to elucidate isotope separation and enrichment processes. In this latter process, an intense pulsed infrared laser vibrationally excites molecules containing the chosen atomic isotope and a second ultraviolet laser photodissociates the molecule, allowing the desired atomic isotope to be collected from the photo fragments. These examples indicate the utilitarian richness of lasers in modern chemistry and illustrate that often they are used in combination with other sophisticated analytical equipment. The facilities investment described here would establish fifteen laser chemistry centers where the operation and maintenance of the lasers would be accomplished by support specialists to serve several research projects. On an even larger scale of centralization, a single free electron laser facility would also be established to provide a very intense and widely tunable source of radiation.

Polymeric materials are found in most military equipment, because of their excellent chemical stability, mechanical properties, and low cost. The majority of the research support for improvements in these materials comes from industry in pursuit of commercial applications, although DOD does support some research specific to stringent military requirements. However, the polymer research of greatest interest to DOD, and for which university facilities upgrades are needed, concerns conducting polymers and polymeric approaches to structural composites, ceramics, and self-reinforcing polymers. It is important to note that independent industrial support of research in these areas is minimal or not aimed at DOD needs.

Conducting polymers that would combine the processability, durability, and light weight of plastics with the electrical conductivity of metal would find a wide range of applications in military systems ranging from solar cells and batteries to integrated circuits and stealth structures. Polyacetylene was the first organic polymer to exhibit electrical conductivity that could range from that of glass to that of metal, depending on the amount of dopants introduced. Doping methods have expanded to include solution doping, ion implantation, and electrochemical doping. Other new polymers have been made conducting, including polypyrrole and polythiophene. Polymer processability and stability are degraded by the doping methods currently used to induce conductivity. Much research is directed at improved doping techniques and on incorporating conducting polymers into nonconducting polymer matrices, as well as fundamental studies to explain the mechanism of electroactivity.

Fiber reinforced composite structural materials are finding many engineering applications, some of which are described under Materials and Engineering. Examples of the Chemistry research topics include organometallic polymer precursors for producing the fibers and self-reinforced or ordered polymers to attain the mechanical properties of fiber-reinforced composites without the need for fiber reinforcement. The most notable of the self-reinforced polymers developed under DOD sponsorship is polybenzothiazole (PBT), which exhibits an extended rigid chain alignment at the ultra-structural level. It offers low-cost processing, by casting and extrusion, instead of the sequence of weaving fibers, stacking of many thin plys, and curing at high temperature required for conventional fiber-reinforced composites.

Other polymeric materials research includes biopolymers, such as the polysaccarides for reduced hydrodynamic drag and non-linear electro-optic polymers for optical signal processing applications. The facilities investment described here would provide the polymer processing and characterization facilities for several focused centers of university research on electrical, optical, magnetic, and structural polymers.

B.2 Electronics

In addition to the traditional subject areas of electronic devices, circuits, and systems, the Electronics research program of DOD encompasses elements of information processing, low energy laser physics, optics, and material growth. For the purposes of this study, the facilities required for the growth of electronic and optical materials are reported under Materials and the low energy lasers, optical circuits, and vacuum tube research facilities are reported under Physics. The information processing research, being closely related to computer science, is not discussed, since, as mentioned in the Introduction, the National Science Foundation (NSF) and the Department of Energy (DOE) have major facilities programs in progress to provide scientific supercomputing access to university researchers. DOD, through the modernization program of the Defense Advanced Research Projects Agency (DARPA), recently made a significant upgrade in university computing facilities for symbolic computing in anticipation of the thrust in strategic computing. The Office of Naval Research is making available to its principal investigators a significant portion of the time of the Naval Research Laboratories' supercomputer at no cost to the existing research contracts.

A strong and clear consensus has emerged from this study indicating that the research managers of the Electronics program within the DOD feel that microcircuit fabrication at dimensions much smaller than those of the Very High Speed Integrated Circuits (VHSIC) program represents the greatest opportunity and greatest research facility need within Electronics. The feature sizes desired are 10 to 100 times smaller than the one-micron regime currently being advanced under VHSIC. It is in this regime that entirely new modes of operation of electronic, optical, and magnetic devices occur, due to the quantum effects produced by the limited number of atoms contained within these small dimensions. These phenomena present the possibility of creating devices whose performance can be greatly superior to that predicted from the bulk characteristics of the material from which they are fabricated. This has already been observed for high speed field effect transistors (FETS), when the device dimensions are reduced below one-tenth micron. It has also been observed that dramatic increases in transmission properties of optical materials occur when very thin layers of material are stacked in a multilayer sequence, offering the possibility of improved photodetectors and lasers.

The fabrication of these novel devices requires very advanced and expensive equipment for the deposition, lithography, and selective removal of the deposited materials. In addition, sensitive analysis of the surfaces and interfaces between dissimilar materials needs to be performed during the fabrication process. This is in contrast to current commercial practice (even for sophisticated microcircuits), where the analysis by electron microscopes and spectrometers is accomplished after the circuits are removed from the fabrication apparatus and before they are inserted into the next apparatus in the fabrication sequence. This requirement for in-situ analysis has greatly increased the minimum cost of doing research on device fabrication.

The facilities in which this instrumentation is housed require extreme control over air purity, to avoid dust particle disruption of the fabrication, and extreme control over vibration, to avoid misalignment of the successive patterns employed in the fabrication sequence. The reliability of these as yet undeveloped circuits is anticipated to be a major concern that is best addressed early in their development, since the failure phenomena are anticipated to be inextricably tied to the fabrication process employed at the microscopic level.

For these reasons, the first priority in microcircuit fabrication was given to the refurbishment and upgrading of up to six university centers for microcircuit fabrication, with a second priority of augmenting two university reliability research centers to work closely on this new class of circuits.

In a separate, but related, research area, reliability at the systems level is perceived to be threatened today by the susceptibility of advanced solid state circuits to electromagnetic interference at relatively modest power levels. Research into hardening weapons systems against intentional enemy electromagnetic interference or inadvertent disruption by radiation from nearby friendly systems is required. The facilities for enabling university participation in this research include anechoic chambers and electromagnetic measurement instrumentation as a first priority, and dedicated computational facilities for modeling as a second priority.

B.3. Engineering

Engineering encompasses the disciplines usually associated with university departments of mechanical engineering, aeronautics and astronautics, civil engineering, industrial engineering, and materials engineering. The subject matter frequently overlaps that of the other disciplines, such as Materials or Chemistry, but is usually closer to a specific end application or requirement. For example, composite structures is a thrust area that has the same ultimate goal as Materials research on structural composites, namely lighter weight and stronger structures for building weapons platforms. The distinction is the focus in Engineering on determining the performance of composites through innovative design and analysis of structures using state-of-the-art materials. Research results are fed back to materials scientists to provide guidance to their endeavors. A base of knowledge about optimal design methods is thereby developed for application to many problems. Proceeding with this example, non-destructive evaluation (NDE) techniques must be developed to enable the engineer to perform these measurements in support of the analysis of composite structures. There is considerable resultant interaction with the materials scientists who also need NDE techniques to evaluate their progress in controlling the composition of materials.

Similarly, the area of Energetic Materials and Combustion involves considerable interaction with chemists to improve propellants, explosives, and fuels. The facilities in these two areas are typically large and have a significant element of concern for the safety of the personnel performing the research. The instrumentation is becoming dominated by lasers and analytical tools similar to that needed in Materials science.

Fluid mechanics and acoustics are the classical, almost exclusive, domain of Engineering, with slight involvement by molecular and chemical physics. The facilities are typified by dedicated wind tunnels and water tunnels. Instrumentation is dominated by automatic digital data acquisition and digital computer modeling and simulation of the phenomena. Laser probes and acoustic sensors with sophisticated signal processing are also mainstays of instrumentation in this discipline.

Manufacturing, design, and reliability have increasingly been moving toward a computer-dominated emphasis on graphics, design aids, expert systems for process control, artificial intelligence to relieve pilot workload in single seat helicopters, and self diagnosis and self repair of machines and weapons systems. Classical industrial engineering, computer science, and structural engineering are very much coming together in this field. The facilities are replicas of factory workcells or simulators of aircraft cockpits and the instrumentation is heavily computer networked. The Defense Advanced Research Projects Agency (DARPA) is making advanced teleconferencing equipment available to several university centers in robotics so they may test their algorithms for robot vision on the DARPA autonomous land vehicle located at a contractor facility. They will also plan to provide replicas of a fingered robot hand to many of these university research centers. Non-destructive evaluation for manufacturing process monitoring and control, as well as for inspection of finished parts and fielded systems, requires a comprehensive research program, which would best be accomplished through a center of excellence in non-destructive evaluation/characterization.

Soil mechanics is uniquely supportive of blast hardened silos, construction, maintenance, and repair of runways, and priority command, control, and communications centers. The facilities at universities are presses, shock tubes, or high-G centrifuges.

B. 4. Materials

Materials research includes the growth of semiconductor, magnetic, and optical materials, as well as processing and fabrication of structural materials such as metal alloys, ceramics, and composites. The processing of semiconductor materials into electronic and optical devices and circuits is reported under Electronics, while the testing of structural composite materials and non-destructive evaluation for both manufacturing and in-process control of materials is reported under Engineering. This traditional division of research responsibility has begun to blur in recent years, and multidisciplinary research teams have been forming in recognition of the strong interaction between material growth, component fabrication, and ultimate system performance. In fact, for optimum coordination, the facilities requirements reported in this section for compound semiconductor growth should be co-located or closely adjacent to the microelectronic fabrication and reliability facilities reported under Electronics.

The greatest potential payoff and also the greatest investment costs are perceived by DOD materials research managers to be associated with two areas: the growth of compound semiconductors and the fabrication of advanced structural composites. High priority at somewhat reduced investment is given to facilities for optical and magnetic materials and for research on structural ceramics.

Compound semiconductor growth has received only a small fraction of the scientific and technical attention that has been spent on silicon. This has been entirely justified to date, since silicon possesses excellent electrical, thermal, and chemical properties, especially with its high quality native oxides and silicides. Being an elemental semiconductor, silicon is significantly simpler from a device processing standpoint than the compound semiconductors, such as gallium arsenide, cadmium telluride, and alloys, e.g. gallium aluminum arsenide and mercury cadmium telluride. The steady doubling of the capability of silicon integrated circuits every two to four years for the past twenty years is evidence of the wisdom of this research investment strategy. It is only recently that the material property limitations of silicon have presented a serious limit to device performance. Research attention is currently turning to at least three ways to get around this limitation. One approach is mentioned in the Electronics section, having to do with new device physics associated with ultra small device dimensions. A second approach, for information processing, is to use artificial intelligence to make "smarter" rather than just "faster" computers. The third approach is to turn significant resources toward the growth and characterization of the compound semiconductors. The facilities investment that is detailed here would permit four to seven university centers to advance the technology of compound semiconductors for signal detection, signal processing, millimeter waves, and communications, to name just a few DOD priority applications.

Composites materials have similar exciting potential for structural applications, ranging from high strength, lightweight airframes and large space structures to lightweight armor for highly mobile combat vehicles. These materials utilize high strength fibers embedded in polymeric, metal, or ceramic matrices. The creation of the fiber itself and the interaction between the fiber and the matrix during the processing largely determine the performance and reliability of the composite when exposed to harsh military environments over its service life. Only recently have advances in analytical tools permitted the microscopic characterization of these materials, both physically and chemically. These tools are both elegant and expensive. The facilities investment detailed here would establish, through new construction and refurbishment, six centers of university research on structural composite materials.

Optical materials are beginning to emerge in communications and signal processing applications. The advances that have been made in optical waveguides using silica glass exemplify the success possible through materials processing research. The combined stringent requirements for low transmission loss and very high tensile strength were achieved through research linking materials structure, properties, and performance. Magnetic materials in bulk form are widely used in critical electrical components, such as electromechanical switches and microwave phased array transmitters and receivers. In thin film form, magnetic materials are used for recording media and non-volatile memory. The facilities investment described here would establish two university centers in optical materials and would augment one existing university center in magnetic materials.

Structural ceramics research of high quality is performed in a number of small university laboratories that are in need of refurbishment and expansion to apply modern microstructural analysis techniques to processing of high temperature ceramics for hostile environments. Both bulk ceramic components, such as radomes for high velocity aircraft, and ceramic coatings on turbine engine components would benefit from this upgraded research capability.

Finally, it should be noted that a segment of the materials research community is dependent upon support from very large research facilities, such as synchrotron and neutron sources. None of these facilities are included in this report. The predominant funding for these national facilities comes from NSF and DOE, with only minor support from DOD. Any decrease in support of these facilities by the other agencies would severely affect the DOD Materials research program.

B.5. Physics

Research on new and improved sources of electromagnetic radiation is a major component of the Physics program of DOD. The free electron laser is a direct result of high risk research funded by DOD. It has demonstrated an entirely new mechanism for generating coherent radiation that is freed from the usual constraints imposed by the need for a material medium. This device has already demonstrated that very wide tunable bandwidth is possible; this has great implications for its utility as a scientific research tool in the analysis of materials, and as a frequency agile radiation source for potential military applications, such as communications and target tracking. Recirculating the electron beam in storage rings offers theoretically high efficiency and hence the potential of high power free electron lasers for directed energy weapons application. The facilities investment reported in this section under coherent radiation sources would refurbish and upgrade three to four existing laboratories performing research on these novel sources.

More conventional lasers for a variety of wavelengths are being explored as tools for research on ultra small integrated circuits, optical computing, catalysis, and molecular biology and for tactical warfare applications such as target designation, optical jamming, and covert communications. The first demonstration of the use of a finely focused laser beam to deposit micron-sized metal connecting lines on semiconductor surfaces occurred under DOD sponsorship in the last five years. It was immediately picked up by the integrated circuit manufacturers as a tool for repairing defects in expensive integrated circuits, and in the photomasks used to produce the circuits. Prior to this breakthrough, lasers had only been used to remove excess material from circuits by vaporizing short circuits and trimming resistors to tolerance. This research continues today under DOD sponsorship and is demonstrating novel methods of doping circuits and of depositing insulators and conductors.

Other laser research projects are attempting to leapfrog over the limitation foreseen in silicon integrated circuits that results from the fact that as much as three-quarters of the surface of these circuits is devoted to metal interconnecting lines between the hundreds of thousands of constituent transistors. The propagation delay of the signals moving on these interconnects at the speed of light is becoming more important in determining the circuit speed than is the switching speed of the transistors. Optical computing chips afford the prospect of distributing the signals by laser beams to many portions of the circuit simultaneously, thereby avoiding the input-output bottleneck of electrical integrated circuits. The facilities reported under optical communications and spectroscopy in this section would establish a new center for optical circuitry and would upgrade an existing laboratory for optical communications.

Directed energy devices require large facilities for research. The high voltages and currents required can only be stored and switched by physically large components as dictated by the scaling laws of electrical power engineering. To some extent this represents a departure from the usual scale of university research funded by DOD, since "big physics" is usually supported by NSF or DOE. DOD has funded university centers in pulsed power, but this has represented only approximately 10 percent of the physics budget. The facilities described under directed energy devices would expand the existing pulsed power centers and upgrade other centers for research on accelerators and microwave and millimeterwave high power sources. Beam propagation and the interaction of electromagnetic energy with materials would also be studied at these centers.

Astrophysics research directly produces knowledge of the background radiation against which space objects must be detected. Secondarily, the advances in instrumentation (optics, infrared, and x-ray) needed to conduct this research improve our military capability to detect and track space objects and to detect nuclear events in space. The major facility upgrade in this section, and indeed, the single highest cost item in the entire report is a $150M high angular resolution imager center whose goal is a hundred-fold increase in image sharpness on celestial objects and space vehicles.

C. SUMMARIES

Laboratory facilities and equipment needs for thrust areas associated with the foregoing disciplines are given in the following summaries. The science and technology implications of laboratory enhancements, and their national security consequences are also addressed.

CHEMISTRY

Thrust Area: Laser Chemistry

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	-- Priority 1 --	
New construction	---	---
Renovation/expansion	20,000	3,000
	-- Priority 2 --	
New construction	75,000	9,000
Renovation/expansion	150,000	13,500
Subtotal	245,000	25,500

Equipment: Linear accelerator and storage ring electron sources; upgrade equipment for free electron laser facility to enhance short wave-length beam power; arrays of six lasers (dye, argon ion), with diagnostic, data processing, and beam direction equipment for each of 15 laser chemistry centers.

Priority	Cost ($ thousands)
1	7,000
2	30,000
Subtotal	37,000

Total Cost: $62,500,000

Technical Objectives and Opportunities:

-- Priority 1 --

An upgraded free electron laser laboratory would be established. It would be a high power, high time resolution facility essential to progress in chemical reaction kinetics, surface physics and chemistry, hot carrier electron transport investigations, and high resolution photo emission studies.

-- Priority 2 --

Fifteen laser chemistry centers would be established. This number represents a best estimate of university community requirements to ensure that DOD-sponsored research in the field is conducted in an efficient, cost-effective manner. Centralized laser resources would facilitate the sharing of expensive instrumentation and permit a reduction of maintenance costs through the pooling of technicians and shop facilities. The centers would include picosecond lasers which, especially in the ultraviolet region, offer a new tool for studying the dynamics of chemical reactions.

National Security Consequences: Fundamental knowledge of chemical reactions is crucial to much of military technology, e.g., to the improvement of propellants, explosives, fuels, lubricants, and high energy lasers.

CHEMISTRY

Thrust Area: Polymeric Materials

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	-- Priority 1 --	
New construction	---	---
Renovation/expansion	15,000	2,000
	-- Priority 2 --	
New construction	170,000	20,500
Renovation/expansion	17,000	1,700
Subtotals	202,000	24,200

Equipment: Polymer molding; film casting; film and fibers drawing/orientation equipment; integrated scanning transmission electron microscopes and x-ray detector systems; SQUID magnetometers; picosecond spectroscopy systems; Fourier transform nuclear magnetic resonance units; electrophoresis equipment; data processing and analysis instrumentation; dedicated computer resources.

Priority	Cost ($ thousands)
1	7,000
2	3,350
Subtotal	10,350

Total Cost: $34,550,000

Technical Objectives and Opportunities:

-- Priority 1 --

Laboratory upgrades would provide significant capabilities for new polymer research at the molecular level, heteroatom polymer synthesis and characterization, characterization of polymers for electronics, etc. Focused centers would be established for the development of a) a new generation of polymers for electronics, optical, and magnetic applications, and b) composite materials with unprecedented toughness and high temperature capabilities.

-- Priority 2 --

The proposed expenditures would greatly enhance research in the areas of composite materials, ordered structural polymers, and polymer thin films for electronics applications. This in turn would lead to the development of improved dielectrics, capacitors, and electroactive polymers for uses such as piezoelectric sensors.

National Security Consequences: Polymer materials are essential elements of virtually all strategic and tactical weapons systems. High temperature metal matrix and ceramic matrix composites for applications such as radiation-hardened structures and gas turbine blades require high temperature fibers. Other applications include cheap, expendable acoustic detectors for sonic buoys, and a variety of electronic microdevices. Improvements in polymeric materials would enhance the performance, reliability, and maintainability of a wide array of weapons systems and logistics equipment.

ELECTRONICS

Thrust Area: Microelectronic Fabrication and Reliability for
Unique DOD-Critical Devices/Materials

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	— Priority 1 —	
New construction	60,000	30,000
Renovation/expansion	60,000	15,000
	— Priority 2 —	
New construction	---	---
Renovation/expansion	20,000	4,000
Subtotal:	140,000	49,000

Equipment: Vacuum and plasma deposition; electron beam and x-ray lithography; plasma etching; wet chemical etching; impurity analysis with electron and ion beams; computational support for device modelling and process simulation; environment simulators for temperature, humidity, vibration, and synchrotron light source for surface diagnostics.

Priority	Cost ($ thousands)
1	30,000
2	6,000
Subtotal:	36,000

Total Cost: $85,000,000

Technical Objectives and Opportunities:

— Priority 1 —

Provide vibration-free facilities for extremely small feature-size (one hundred angstrom) micro-circuit fabrication of devices utilizing technology beyond VHSIC. Electron-beam and x-ray lithographic equipment and plasma and laser enhanced photo deposition apparatus are required. Electron and ion-beam imaging systems for measurement analysis of ultra small structures are necessary.

— Priority 2 —

Establish research capability in reliability of micro-circuit devices, especially with respect to temperature, humidity, and radiation hardness of ultra small devices. Expand synchrotron analysis capability for analysis of electrical contacts and other natural interfaces.

National Security Consequences: Integrated circuit fabrication is pressing the limits of our knowledge of chemistry and physics, particularly of interfaces between materials, and the utilization of unique materials for DOD devices. Research to provide the knowledge required for further advances in integrated circuits can only come if researchers in university laboratories have access to state-of-the-art fabrication equipment and processes. Reliability of military systems using integrated circuits depends to a large extent on the processes used to fabricate circuits and their stability over time.

ELECTRONICS

Thrust Area: System Robustness and Survivability

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost $ thousands)
	-- Priority 1 --	
New construction	---	---
Renovation/expansion	10,000	4,000
	-- Priority 2 --	
New construction	---	---
Renovation/expansion	5,000	2,000
Subtotal:	15,000	6,000

Equipment: Electromagnetic generators; anechaic chambers; microwave measurement equipment; propagation ranges; computation facilities for modelling and diagnostics.

Priority	Cost ($ thousands)
1	3,000
2	2,000
Subtotal:	5,000

Total Cost: $11,000,000

Technical Objectives and Opportunities:

-- Priority 1 --

Expand existing facilities for the measurement of electromagnetic propagation, measurement, and system network investigations.

-- Priority 2 --

Provide computational facilities to enhance modeling of electromagnetic interference phenomena.

National Security Consequences: Sophisticated weapon systems are potentially vulnerable to electro-magnetic interference, either consciously induced by enemy forces or unintentionally introduced through radiation from friendly force equipment. Subtle interactions between electronic systems operating on the same platform can degrade performance or completely deny weapon systems availability. Fundamental scientific understanding of means for minimizing these effects is required to supplement the current engineering fixes being pursued.

ENGINEERING

Thrust Area: Combustion

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	— Priority 1 —	
New construction	57,500	9,250
Renovation/expansion	95,000	8,600
	— Priority 2 —	
New construction	---	---
Renovation/expansion	9,300	1,250
Subtotal	161,800	19,100

Equipment: Variable high-pressure flow reactors; optical diagnostic instrumentation; chemical analysis instrumentation; vector processors for the simulation of turbulent multiphase processes; dedicated computer diagnostic and analysis capabilities.

Priority	Cost ($ thousands)
1	15,000
2	11,750
Subtotal	26,750

Total Cost: $45,850,000

Technical Objectives and Opportunities:

— Priority 1 —

Conduct research on improving the energy efficiency of turbine and internal combustion engines, investigate the viability of alternate fuels (e.g., methanol), develop insights into high-pressure, high-temperature combustion chemistry of present and future propulsion fuels, study multiphase turbulent reacting fuels, and observe high altitude and high mach number combustion processes.

— Priority 2 —

Develop unique facility for studying combustion and plasma phenomena of propulsion systems; anticipated benefits include increased understanding of ramjet and rocket motor instabilities, fire propagation phenomena ignition and flame propagation mechanisms, and plasma/gas dynamic interactions. Upgrade facility for quantitative flow field imaging to advance understanding of phenomena underlying energy conversion, aerodynamics, and propulsion processes.

National Security Consequences: Improve the range, performance, and reliability of aircraft, missile, ship, and land vehicle propulsion systems; enhance payloads, lower operating costs, reduce corrosion and detectable exhaust signatures, increase fuel performance, and reduce engine development time.

ENGINEERING

Thrust Area: Composite Structures

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	— Priority 1 —	
New construction	---	---
Renovation/expansion	5,000	1,180
	— Priority 2 — N/A	
Subtotals	5,000	1,180

Equipment: Mechanical testing devices capable of multiaxial and variable loading rates in high temperature environments; real-time non-destructive ultrasonic, acoustic emission and x-ray radiography testing equipment; high temperature test equipment with associated data processing and dedicated computational capability.

Priority	Cost ($ thousands)
1	3,420
2	---
Subtotal	3,420

Total Cost: $4,600,000

Technical Objectives and Opportunities:

— Priority 1 —

Composite materials have not been exploited to the degree possible, due to a lack of detailed understanding of their response to complex loading conditions, high strain rates, and hostile environments. The proposed facility would likely engender major advances in the understanding of the thermomechanical behavior and failure characteristics of composite materials, with emphasis on high temperature conditions.

— Priority 2 —

N/A

National Security Consequences: Military applications of composite materials include engine hot sections, nozzles, missile nose cones, aircraft surfaces, lightweight high-strength materials, etc. Improved materials are key to enhancing the performance and maintainability of weapons systems and logistics equipment.

ENGINEERING

Thrust Area: Energetic Materials

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	-- Priority 1 --	
New construction	---	---
Renovation/expansion	---	1,000
	-- Priority 2 -- N/A	
Subtotals	0	1,000

Equipment: Mechanical and x-ray diagnostic devices; time-resolved optical spectrometer; electromagnetics effects sensor; gas guns; sample preparation equipment; specialized machine shops.

Priority	Cost ($ thousands)
1	7,000
2	---
Subtotal	7,000

Total Cost: $8,000,000

Technical Objectives and Opportunities:

-- Priority 1 --

A primary objective is the development of a broad class of high performance propellants. A second priority objective is research on energetic materials (explosives, propellants, etc.) which remain inert under shock conditions. This involves theoretical and experimental investigations of atomic and molecular processes in shocked condensed wave materials. Experimental research would provide time-resolved optical, x-ray, electrical, and mechanical diagnostics on materials stimulated by mechanical impactors or lasers.

-- Priority 2 --
N/A

National Security Consequences: Inadvertent ignition of explosives and propellants under mechanical shock and thermal stress is a significant operational hazard, particularly under combat conditions. The development of energetic materials which a) are relatively inert to those stresses, and b) function optimally on command, would mitigate this problem.

ENGINEERING

Thrust Area: Fluid Mechanics and Acoustics

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	-- Priority 1 --	
New construction	---	---
Renovation/expansion	7,000	650
	-- Priority 2 --	
New construction	---	---
Renovation/expansion	---	350
Subtotals	7,000	1,000

Equipment: State-of-the-art instrumentation for physical acoustics research including highly stabilized lasers, cryogenic equipment, and digital processing gear for automating signal detection and data processing; instrumentation and support equipment for wind and water tunnel facilities for the upgrading of data acquistion and reduction capabilities. For water tunnels, traverse mechanisms, non-linear wave generators, current generators, and related measuring instruments are needed. Wind tunnel requirements include a multi-axis, three-dimensional laser doppler anemometer, and equipment for generating oscillatory flows.

Priority	Cost ($ thousands)
1	3,600
2	3,350
Subtotal	6,950

Total Cost: $7,950,000

Technical Objectives and Opportunities:

— Priority 1 —

-- Wind tunnels facilities - provide a national resource for studying turbulent and unsteady flows in Reynolds number regimes typical of subsonic flight, and a second facility devoted to the study of the physics of separated flows and transitioning boundary layers. This research could lead to the development of revolutionary concepts of, and predictive methods for, flow management and control in the flight vehicle environment.

-- Water tunnel facility - upgrade an existing facility to greatly reduce flow noise inherent in present tunnel configurations. This improvement would facilitate research on reducing flow noise due to turbulent boundary layer flow around ship hulls.

— Priority 2 —

-- Wind tunnel facilities - modifications at two sites to facilitate a) research on the prediction of the transition from laminar to turbulent flow and its impact on vehicle drag, and b) low turbulence flow phenomena with emphasis on associated viscous effects, leading to improvements in aircraft design and control technology.

-- Studies of nonlinear surface wave mechanics to enhance understanding of wave/wave/current interactions, ocean wave/ship wake interaction processes, and associated underwater acoustics, leading to improvements in ship designs, wake signature reduction, etc.

-- Integrated physical acoustics laboratory to facilitate research in sound propagation and attenuation, molecular and chemical physics, and underwater acoustics.

National Security Consequences: The proposed facilities enhancements would support research critical to improved aircraft performance, range, payload, and fuel efficiency. Defense applications of water tunnel upgrades include improved range and performance of ships (surface and submersible), reduction of noise signatures of submarines, and enhanced performance of acoustic sensors through the reduction of host-sensor interference.

ENGINEERING

Thrust Area: Manufacturing, Design, and Reliability

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	— Priority 1 —	
New construction	77,000	9,250
Renovation/expansion	55,000	6,250
	— Priority 2 —	
New construction	10,000	1,200
Renovation/expaansion	20,000	4,500
Subtotals	162,000	21,200

Equipment: Hardware and software for design of component inspectability and manufacturing process control functions; integration of advanced nondestructive testing capabilities with computer-aided mechanical design methods; modernization of dynamic track facility including electronic sensors and displays, simulators, and noise and vibration sensors; human factors diagnostic equipment; avionics gear; combustion diagnostic equipment.

Priority	Cost ($ thousands)
1	10,000
2	3,000
Subtotal	13,000

Total Cost: $34,200,000

Technical Objectives and Opportunities:

— Priority 1 —

Advances in manufacturing methods having DOD-wide implications for reducing weapons system life-cycle cost, and for enhancing systems reliability, would be pursued. Ancillary objectives include reduced lead times and product development costs, improved productivity and quality control, and reduced inventory costs. A new, unique interdisciplinary manufacturing technology facility emphasizing optimal materials utilization and product reliability would be established. Emphasis would be placed on applications of artificial intelligence concepts to the manufacturing cycle. A second laboratory would be developed for studying the application of computers to the design, manufacture, and control of complex systems, and for the development of advanced composite materials.

Integrated, coordinated research into all aspects of rotorcraft design, manufacturing, and performance at two laboratories is a second objective of the proposed expenditures. Areas of concentration include computer-aided design and manufacturing of rotorcraft components, the study of human factors problems associated with the workload of single pilots in a high performance rotorcraft, stability and control research, and combustion studies aimed at enhancing engine performance.

— Priority 2 —

Factory of the future concepts would be explored combining manufacturing physics and artifical intelligence, with emphasis on the development of unmanned, self-diagnostic, and self-repairing machines and robots.

Upgrades of two more rotorcraft laboratories addressing the technical issues outlined for Priority 1 would be made possible, with emphasis on rotorcraft dynamics and avionics, respectively.

National Security Consequences: Procurement and maintenance cost-containment are key considerations in the DOD budget. The proposed facilities would support research directed toward these goals. Improved quality control would enhance product reliability. Army mobility rests to a great extent on rotorcraft (helicopter) performance capabilities, including speed, lift capacity, payload, and crash-worthiness. The proposed facility expenditures would address all of these factors in a much more comprehensive manner than is now feasible.

ENGINEERING

Thrust Area: Soil Mechanics

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	-- Priority 1 -- N/A	
	-- Priority 2 --	
New construction	6,000	1,600
Renovation/expansion	---	---
Subtotal	6,000	1,600

Equipment: Four hundred G-ton centrifuge with support apparatus.

Priority	Cost ($ thousands)
1	N/A
2	200
Subtotal	200

Total Cost: $1,800,000

Technical Objectives and Opportunities:

-- Priority 1 --
N/A

-- Priority 2 --
The centrifuge would permit the study of soil and structure phenomena in realistic stress regimes not possible with present facilities. The laboratory would be developed to study both static and dynamic loadings.

National Security Consequences: Research would be applicable to the development of improved structures for missile silos and hardened tactical facilities.

MATERIALS

Thrust Area: Optical and Magnetic Materials

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	-- Priority 1 --	
New construction	10,000	3,000
Renovation/expansion	15,000	2,000
	-- Priority 2 --	
New construction	---	---
Renovation/expansion	10,000	2,000
Subtotal:	35,000	7,000

Equipment: Preparation and handling facilities; high vacuum furnaces; computer-controlled annealing ovens; fiber extrusion and cladding apparatus; grinding and polishing equipment; electron beam microscopes; laser diagnostic facilities; secondary ion mass spectrometers; electron spectrometers; Raman surface spectrometers; high field magnets; casting/grinding/magnetic aligning/sintering equipment operating in "oxygen-free" atmospheres.

Priority	Cost ($ thousands)
1	2,300
2	1,000
Subtotal:	3,300

Total Cost: $10,300,000

Technical Objectives and Opportunities:

-- Priority 1 --

Establish two university centers of excellence in optical materials for both fiber-optic applications and integrated optics circuits for signal processing. Facilities should include material growth, device fabrication, and evaluation capabilities. The centers would generate benefits in such DOD high pay-off areas as durable low loss fibers, laser sources in the ultraviolet and visible wavelength ranges, detectors in the 8-14 micron region, vapor processing/deposition processes, non-linear optical materials, etc.

-- Priority 2 --

Expand existing capability in magnetic materials for improvements in field strength and in temperature operating range of rare earth magnet materials. Research emphasis would be on materials characterization and structure definition using Mossbauer, x-ray diffraction, scanning transmission electron microscope, and neutron diffraction methods.

National Security Consequences: Optical materials are assuming greater significance to defense systems for surveillance, laser designation, and high energy laser weaponry. In addition, optical signal processing may provide an alternate to conventional integrated circuits for information processing. Magnetic materials are currently used in microwave transmitting devices, switching devices, and in non-volatile memory systems for crucial military information processing and communciation systems.

MATERIALS

Thrust Area: Silicon and Compound Semiconductor Growth

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	-- Priority 1 --	
New construction	20,000	15,000
Renovation/expansion	40,000	8,000
	-- Priority 2 --	
New construction	---	---
Renovation/expansion	40,000	10,000
Subtotal:	100,000	33,000

Equipment: Molecular beam epitaxy; metal organic chemical vapor deposition electron beam diagnostics; laser probe diagnostics; mass spectrometry.

Priority	Cost ($ thousands)
1	30,000
2	10,000
Subtotal:	40,000

Total Cost: $73,000,000

Technical Objectives and Opportunities:

-- Priority 1 --

Crystal growth facilities for low defect silicon and for device quality gallium arsenide and gallium aluminum arsenide are required. Instrumentation in this area combines growth with evaluation of materials within the same deposition chambers. By contrast, in commercial practice crystal growth of bulk ingots is performed in an activity separate from the evaluation of the grown material. These facilities are extremely expensive and are in the laboratory apparatus phase currently, with few commerical instruments being available.

-- Priority 2 --

Crystal growth facilities for advanced compound semi-conductors such as mercury cadmium telluride are required for the improvement of optical as well as electronic devices. Relatively little research has been done on the application of modern growth techniques to these compounds, largely because of the attention focused on silicon and gallium arsenide.

National Security Consequences: Integrated circuits are at the heart of most modern military systems, from command and control to smart weapons. The VHSIC program has made a major advance in the capability of these devices, by reducing the feature size down to the one micron regime. Future advances in this circuitry will require greater fundamental understanding of the functioning of conventional integrated circuits. For feature sizes even smaller than this, quantum effects will introduce wholly new device phenomena, presenting major opportunities for advancement in information processing capabilty. Examples of technology applications include infra-red focal plane array detectors, integrated optics, millimeter and microwave integrated circuits, and optoelectronics.

MATERIALS

Thrust Area: Structural Ceramics

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	-- Priority 1 --	
New construction	20,000	3,000
Renovation/expansion	5,000	1,000
	-- Priority 2 --	
New construction	30,000	5,000
Renovation/expansion	10,000	2,000
Subtotal:	65,000	11,000

Equipment: Ball milling and mixing equipment; hot isostatic presses; vacuum and controlled atmosphere furnaces; fume hoods; surface analysis equipment; scanning electron microscopes; secondary ion mass spectrometers; x-ray diffractometers; computational facilities for data acquisition and process modelling.

Priority	Cost ($ thousands)
1	9,800
2	5,400
Subtotal:	15,200

Total Cost: $26,200,000

Technical Objectives and Opportunities:

-- Priority 1 --

Three university laboratories currently involved in ceramics research would be upgraded. The primary benefits include enhanced understanding of the fundamental relationships between (a) ceramics constituents and processing techniques, and (b) material properties, reproducibility, and reliability. Elucidation of these governing factors should greatly reduce the time required to develop improved ceramic materials and composites. Principal research benefits envisioned include development of non-destructive evaluation techniques, methods for the deposition of ceramic coatings using plasma techniques, and development of materials which will tolerate severe thermal shock and sustained high temperatures, and which have uniform, reproducible microstructures.

-- Priority 2 --

Three additional laboratory facilities would be expanded in the context of the above rationale.

National Security Consequences: In hostile environments, metal surfaces oxidize, corrode because of stress, fail because of fatigue, exhibit effects from laser radiation and interfacial phenomena, and are subjected to friction and wear. Ceramic materials are used in extremely hostile environments in turbine engines, rocket nozzles, and electromagnetic windows of high velocity aircraft and missiles.

MATERIALS

Thrust Area: Structural Composites

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	-- Priority 1 --	
New construction	50,000	15,000
Renovation/expansion	60,000	8,000
	-- Priority 2 --	
New construction	---	---
Renovation/expansion	80,000	10,000
Subtotal:	190,000	33,000

Equipment: Vapor deposition epitaxy reactors; filament winders; squeeze casting presses; injection molding presses; textile forming looms; thermoforming presses; servo-hydraulic forming equipment; powder processing and fiber growth equipment; special equipment for ceramics processing; high temperature/high pressure autoclaves; process control computers; diagnostic and modeling computers and graphics.

Priority	Cost ($ thousands)
1	20,000
2	20,000
Subtotal:	40,000

Total Cost: $73,000,000

Technical Objectives and Opportunities:

-- Priority 1 --

Establish four major university centers of excellence in the fabrication of fiber and matrix materials, emphasizing polymer matrix and ceramic matrix materials. Capabilities should include fabrication and layup of small samples and diagnostic materials for the analysis of thermophysical and thermomechanical properties.

-- Priority 2 --

Supplement the above with three to four additional university centers with similar missions.

National Security Consequences: Lightweight and high strength composite materials are increasingly being used in aircraft and spacecraft. These materials combine the high strength of ceramic fibers with the ductility of polymeric or metallic matrices. Significant performance advantages have already been obtained through the use of composite materials, including ceramic matrix composites, and further performance advantages are foreseen, particularly with regard to high temperature capability, laser hardness, armor, and low observables.

PHYSICS

Thrust Area: Astrophysics

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	-- Priority 1 -- N/A	
	-- Priority 2 --	
New construction	68,000	11,550
Renovation/expansion	35,000	5,100
Subtotal:	103,000	16,650

Equipment: Radio, optical, and x-ray astronomy equipment; upgrade of 100 inch aperture telescope for active optics and interferometric imaging; high angular resolution imager with one milliarcsecond resolution and optical elements of 7 1/2 meters; 4-meter telescope for optical/infrared imaging and spectroscopy.

Priority	Cost ($ thousands)
1	N/A
2	152,065*
Subtotal:	152,065

Total Cost: $168,715,000

* Includes $150,000,000 for high angular resolution imager.

Technical Objectives and Opportunities:

-- Priority 1 --
N/A
-- Priority 2 --

- Expand laboratory capabilities in radio, optical, and x-ray astronomy to study final stages of evolution of stars, formation of neutron stars and black holes, the occurrence of supernova, and to elucidate recently observed non-thermal radio sources.

- Extend existing capabilities in active optics, speckle imaging techniques, and advanced detector programs to existing telescope to produce diffraction-limited imaging of astrophysical sources.

- Establish high angular resolution imager center which exploits advances in optics, sensors, and computer technology to afford a hundred-fold increase in image sharpness on celestial objects (quasar nuclei, stellar, and solar system object surface features) and space vehicles.

- Develop new optical and infrared telescope/instrumentation for astrophysics applications embodying improved precision pointing and tracking, image quality optimization, advances in optical and infrared technology, high speed two-dimensional photon detectors, etc.

National Security Consequences: Advances in astrophysics-related imaging techniques have important applications for the detection and identification of space and non-space objects of military significance. In particular, the technological development of active optics in combination with speckle imaging will make possible diffraction limited observations of objects through the atmosphere. The enhancement of x-ray instrumentation capabilities has application to the detection of nuclear events in space.

PHYSICS

Thrust Area: Coherent Radiation Sources

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	-- Priority 1 --	
New construction	---	---
Renovation/expansion	17,000	2,500
	-- Priority 2 --	
New construction	---	---
Renovation/expansion	---	4,000
Subtotal:	17,000	6,500

Equipment: Tunable two-beam two-stage free electron lasers; millimeter range free electron laser; mode-locked laser and support equipment; spectrographs for optical emission spectroscopy; electronic processing equipment (lithographic, deposition, etching); auxiliary interface and support equipment.

Priority	Cost ($ thousands)
1	1,500
2	6,250
Subtotal:	7,750

Total Cost: $14,250,000

Technical Objectives and Opportunities:

-- Priority 1 --

Laser facilities are key assets for a variety of materials and directed energy related research. The cited expenditures would substantially enhance the capability of universities to explore and expand technology horizons in electronic materials, catalysis, corrosion, and molecular biology, among others. Emphasis is on more broadly tunable lasers, which generate coherent radiation over a wide range of energies. This greatly enhances the flexibility available to researchers for analyzing material properties, particular surfaces, and interfaces of importance to solid state electronics and optoelectronics.

-- Priority 2 --

Laser-guided plasma and electron beam facility upgrades will allow the university community to explore more efficiently and comprehensively heretofore unknown aspects of directed energy propagation concepts.

National Security Consequences: Coherent radiation research is critical to a variety of DOD R&D missions, including the design of directed energy weapons, propagation (e.g., "channeling") of charged particle beams, improvement of high power radar technology and electronic countermeasures, advances in ultra-small electronic devices, optical storage and switching aspects of ultra-fast optical computers, etc. High average moderate power tunable lasers are expected to have important implications for tactical applications related to electronic warfare.

PHYSICS

Thrust Area: Directed Energy Devices

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	-- Priority 1 --	
New construction	---	---
Renovation/expansion	63,000	13,250
	-- Priority 2 --	
New construction	---	---
Renovation/expansion	20,000	4,000
Subtotal:	83,000	17,250

Equipment: Hardware to enlarge accelerator power supplies and capacitor banks; vacuum tube fabrication equipment; large electric discharge chambers; pulsed power generator; high-power glass laser; dedicated data acquisition and analysis computer facilities.

Priority	Cost ($ thousands)
1	6,250
2	4,000
Subtotal:	10,250

Total Cost: $27,500,000

Technical Objectives and Opportunities:

-- Priority 1 --

- Upgrade stellatron accelerator facility as a testbed for high current, high energy accelerators, including screen room and associated diagnostic instrumentation. Facility would generate data of use in the development of compact, high performance accelerators in the non-linear beam interaction regime.
- Establish center for research on thermionic sources of millimeter wave radiation at megawatt power levels. The facility would provide understanding electron-electromagnetic field interactions leading to the development of Rf sources in a regime extending to 30 THZ.
- Develop high repetition rate, high average power pulsed power facilities to support studies in plasma beam propagation, microwave power generation, and the interaction of electromagnetic radiation with materials.

-- Priority 2 --

- Expand center for research on switches and power conditioners for extremely high voltages and high currents. Research in this area is heavily dependent on the existence of specialized facilities.

National Security Consequences: Compact high current, high energy accelerators are key components in charged and neutral particle beam weapons concepts. Thermionic radiation sources are essential components of and/or have implications for fusion power sources, directed energy weapons, and spacecraft vulnerability questions associated with ion clouds in space. High voltage and high current switches, regulators, and storage devices are required to operate directed energy weapons. The development of repetitive and reliable opening switches would remove significant impediments to the practical implementation of all directed energy devices.

PHYSICS

Thrust Area: Optical Communications and Spectroscopy

Laboratory Needs

Facilities:	Building Requirements (gross ft^2)	Total Facility Cost ($ thousands)
	-- Priority 1 --	
	N/A	
	-- Priority 2 --	
New Construction	8,000	1,000
Renovation/expansion	---	---
Subtotal:	8,000	1,000

Equipment: Lasers (stable argon ion, ring, picosecond CO_2, femtosecond dye and YAG, mode-locked glass); transient digitizers; computational and digital signal processing capabilities; scanning electron microscope; optical components with special coatings.

Priority	Cost ($ thousands)
1	1,550
2	950
Subtotal:	2,500

Total Cost: $3,500,000

Technical Objectives and Opportunities:

-- Priority 1 --

Laboratory upgrade would facilitate research leading to a better understanding of the fundamental processes and interactions in semiconductors and microstructures necessary for the development of ultra-fast semiconductor electronic devices.

-- Priority 2 --

- Laboratory improvement would permit detection of weak signals which arise in many photon statistic experiments. For example, the creation of photon pairs through non-linear processes followed by subsequent simultaneous detection (i.e. correlation experiments) generally produces weak signals. Such phenomena could greatly expand communication signal detection capabilities.

- A Center for Optical Circuitry would be established for optical computing. It offers the possibility of great advances in computing speed, capacity, and degree of parallelism over electronic computing. Dramatic new computer architectures are possible, e.g., three-dimensional logic and storage.

National Security Consequences: A wide variety of defense-related technology improvements are based on progress in the development of extremely fast and compact electron devices for digital and analog applications. These include smart weapons and surveillance systems. In addition, secure optical communications have important applications to C3.

CHAPTER V

DISCUSSION AND RECOMMENDATIONS

A. DISCUSSION

The laboratory needs cited in Chapter IV relate to universities already heavily involved in conducting research for DOD. They represent a small subset of the 157 colleges and universities addressed in Tables III-4 and 5, and an even smaller segment of all research universities included in Tables III-2 and 3. The AAU study summarized in Table III-1 equates with this work most readily in terms of the number of institutions covered.

Summary comparisons follow between the prior laboratory assessments cited in Chapter III and the present work given in Chapter IV. It should be emphasized that these comparisons involve the DOD-specific laboratory needs developed in this report as opposed to more general needs addressed in prior studies. Nonetheless, they suggest that the cumulative expenditures discussed in Chapter IV are of reasonable magnitude in the context of general university laboratory needs identified in other studies.

- The AAU data shown in Table III-1 relate to 15 universities, a figure roughly equivalent to the average number of institutions encompassed by defense-related laboratory needs for each of the disciplines cited in Table IV-1. This probably accounts for the fact that, for some disciplines, defense-related totals substantially exceed the AAU report figures. Interpretations of these comparisons must be tempered by the fact that the discipline-specific university populations encompassed within the present study differ markedly from the AAU sample population. A Comparison of Tables III-1 and IV-1 indicates that the defense-related facilities needs cited in this report constitute 43 percent of the AAU Chemical Sciences projections for the period 1982-84, over 100 percent for Engineering (encompassing the Electronics, Engineering, and Materials categories of Table IV-1), and 55 percent for Physics. For projected equipment needs, those of this study exceed the AAU figures by factors of roughly three and six for Chemical Sciences and Engineering. The numbers are comparable for Physics, excluding the astrophysics high resolution imager cited in the present study.

- According to NSF staff, an estimated 50 percent to 70 percent of the $221 million cited in Table III-2 for 1983 university capital expenditures (research and instructional) was devoted to research laboratory facilities. Assuming, for purposes of comparison, a 60 percent figure, 1983 research laboratory expenditures for all universities in the engineering and physical science disciplines total $133 million. To obtain a roughly comparable figure, one can annualize the $275 million of defense-related engineering and physical sciences facilities needs (Table IV-1) over a five-year period. This yields an annual expenditure rate of $55 million. It represents slightly more than 40 percent of the estimated $133 million spent by all universities.

- Research equipment expenditures for all U.S. colleges and universities are summarized in Table III-3 for Engineering, Chemistry, and Physics and Astronomy. Engineering expenditures average approximately $70 million for the two-year period. The NSF Engineering category compares roughly to the combined Engineering, Electronics, and Materials categories of this report, where priority 1 and 2 equipment needs shown in Table IV-1 total almost $200 million. If the $200 million is annualized over a five-year period, approximately $40 million in FY 85 dollars would be spent for defense-related equipment annually. This represents over 55 percent of the average 1982-83 engineering annual equipment expenditures for all higher education institutions. Similar analyses for physics and chemistry suggest that needs in these areas cited in Table IV-1 pro-rated over five years are approximately $35 million and $9.5 million, respectively. The projected annual physics expenditure is roughly equal to the NSF 1982-83 average for all universities, largely due to a $150 million high resolution imager for astrophysics. Similarly, the projected chemistry annual expenditures are 30 percent of the average for all U.S. universities for the two-year period.

- Column two of Table III-4 lists 1982 research equipment expenditures for the top 157 research universities. As in Table III-3, the NSF Engineering category compares roughly to the combined Engineering, Electronics, and Materials categories of this report, whose equipment needs total approximately $200 million. Assuming again that expenditures for defense-related laboratory equipment needs would be spread over a five-year period, approximately $40 million in FY 85 dollars would be spent for this purpose annually. This represents roughly 45 percent of the 1982 expenditures for the 157 universities. Similarly, the five year annual expenditure level for physics from Table IV-1 is over 60 percent of the 1982 equipment purchase level, largely due to the inclusion of the aforementioned $150 million high resolution imager for astrophysics applications. The five-year expenditure level implied for chemistry in Table IV-1 is $9.5 million, or approximately 25 percent of the stated 1982 expenditures by the 157 universities.

- The replacement value of "academic research instrument systems in active research use" for the aforementioned 157 universities is given in Table III-3 in terms of 1982 dollars (Column 4). With an inflation factor of 1.076 applied to the 1982 costs, Table V-1 gives priority 1 and 2 (total) defense-related equipment needs from Table IV-1 expressed as percentages of Table III-5 replacement values. As before, the NSF Engineering category encompasses the Electronics, Engineering, and Materials categories of this report. For the Engineering and Physics and Astronomy categories, stated defense-related needs are quite substantial in comparison with the NSF equipment replacement figures. The Chemistry percentage is substantially lower, perhaps reflecting a proportionately lesser DOD involvement in broad aspects of experimental chemistry.

Table V-I

Defense-related university laboratory equipment needs (Table IV-1) expressed as percentages of replacement costs for all research equipment at 157 leading research universities (Table III-5)

Field of Research	% of Replacement Value
Chemistry	15
Engineering	44
Physics and Astronomy	68

B. RECOMMENDATIONS

A total of $300 million over a five (5) year period is proposed for the upgrading of university laboratories.

1. The priority 1 laboratory facilities needs cited in Table IV-1 should be addressed with incremental funding of a five-year $150 million initiative. The initiative should be a part of, and administered through, the existing contract research programs of the OXRs and DARPA. It is believed that this is the most efficient mechanism for targeting facilities improvement funds toward the highest DOD research priorities. This program would be of equal magnitude (i.e. $150 million expended at an annual rate of $30 million) to the existing University Research Instrumentation Program (URIP) pertaining to equipment, but would be allocated as facilities-earmarked increments to competitive research awards. It would thus differ from URIP in that it would not require the establishment of separate review and award mechanisms. It should be stressed that, in the best interests of national security, neither equipment nor facilities upgrade programs should be funded at the expense of existing OXR and DARPA competitive research programs. Further erosion of the latter would jeopardize the scientific basis for future technological innovation on which our national security depends.

2. The existing URIP program should be extended by three years at its present level of $30 million per year. This, combined with the remaining two years ($60 million) of the present program, would constitute the $150 million required to address priority 1 equipment needs (Table IV-1).

3. Priority 2 laboratory needs should be addressed as a national issue with the involvement of other federal agencies having an impact on the national science and technology base, i.e. the National Science Foundation, NASA, Department of Energy, etc.

4. Very large items of equipment and/or facility needs, e.g. the $150 million astrophysics high resolution imager cited in this report, should be addressed on their merits as individual appropriations rather than as parts of broader, more general funding initiatives.

APPENDIX

STUDIES OF ACADEMIC FACILITIES*

Study	Description of Study	Findings
"Health Related Research Facilities in the U.S. in the Nonprofit Nonfederal Sector" Study by Westat Corporation for National Institute of Health (NIH) (1969)	Survey study to gather data on the amount, age and ownership of space in 1968, the amount of space under or scheduled for construction and the estimated space needed to eliminate overcrowding by 1980	10 m. of 42 m. sq. ft. in unsatisfactory condition -over 50% available space in poor condition -additional 55 m. square feet of space needed by 1980, with 17 m. square feet requiring remodeling
"Higher Education General Information Survey" (HEGIS) Conducted by the National Center for Educational Statistics (NCES) (1974)	Survey of 3,200 colleges and universities including data to estimate facilities needs	-20% of facilities at surveyed institutions in need of replacement (2.3 billion square feet) -$2. billion needed just for remodeling of facilities
"Health Research Facilities: A Survey of Doctorate-Granting Institutions." Conducted by American Council on Education (ACE) with funding from National Science Foundation (NSF) and NIH (1976)	Survey of 155 Ph.D. granting institutions to gather data on status of academic health research facilities, new construction in progress, and plans for expansion in succeeding five year period	-29% of academic facilities for health research in need of renovation or replacement (23 million square feet) -cost estimates to meet needs: $547 million for 1975; $560 million for each of succeeding five years
"National Survey of Laboratory Animal Facilities and Resources" Conducted by National Academy of Sciences (NAS) (NIH Publication No. 80-2091) (1978)	Survey of 922 nonprofit NIH eligible institutions gathering data to estimate facilities needs	-16% institutions reported need for replacement of facilities -38% reported need for remodeling of facilities -47% reported need for additional space

*Source: Linda S. Wilson, "The Capital Facilities Dilemma: Implications for Graduate Education and Research", to be included in forthcoming Brookings Institution study, Bruce L. R. Smith, editor, The State of Graduate Education, 1985.

STUDIES OF ACADEMIC FACILITIES

Study	Description of Study	Findings
Report of Research Facilities Branch of National Cancer Institute on survey of facilities needs in cancer research Conducted at request of National Cancer Advisory Board (1979)	Survey of 106 institutions receiving National Cancer Institute Support gathering data to evaluate current and future needs for upgrading of cancer research facilities	Funding need of $149 million for the period 1980-1985 estimated for cancer research facilities
"A Program for Renewed Partnership" Prepared by the Sloan Commission on Higher Education (1980)	Commission report on federal government/university relations (No data collected)	-Recommendations for competitive program for facilities research grants; $50 million annually for five years, to be allocated by NSF and NIH, to upgrade research laboratories and equipment
"The Nation's Deteriorating Research Facilities: A Survey of Recent Expenditures and Projected Needs in Fifteen Universities" Conducted by the Association of American Universities (AAU) (1981)	Survey of 15 leading universities gathering data on expenditures for research facilities and major equipment and estimates of funding needs for succeeding three year period for faculty research only	-From 1972-1982, surveyed institutions spent $400 million for facilities construction, repair, and renovation -$765 million needed for facilities and equipment over succeeding three year period just to sustain faculty research activities

STUDIES OF ACADEMIC FACILITIES

Study	Description of Study	Findings
Report on academic facilities survey (in 1980-81 Comparative Cost and Staffing Report) Conducted by Association of Physical Plant Administrators (APPA) (1981)	Survey of 226 institutions with 434 million square feet of academic space to gather data on facilities conditions and projected needs	-$1.85-$2.00/square foot required to eliminate most pressing needs -deferred maintenance need per institution of $9.5 million at universities $1.1 million at four year colleges $.4 million at two year colleges
"Strengthening the Government-University Partnership in Science" Conducted by Ad Hoc Committee of NAS, National Academy of Engineering and Institute of Medicine (1983)	Committee report on federal government/university relations (no data gathered)	-Critical, growing need for replacement of academic science facilities and equipment -recommends comprehensive program for facilities construction and development, acquisition, maintenance and operation of modern equipment
"Adequacy of Academic Research Facilities" Conducted by Ad Hoc Interagency Steering Committee on Academic Research Facilities (April, 1984) National Science Foundation	Pilot study of 25 major research institutions with major study planned to gather data for detailed analysis of the condition of facilities used for science and engineering and medical research. Major study to estimate future needs for construction, remodeling and refurbishment of academic research facilities	-Over succeeding 5 year period all colleges and universities would require about $1.3 billion per year for research facilities alone. (Note: Present level of capital facilities expenditures for academic research, development and instruction is $1 billion per year.)

STUDIES OF ACADEMIC FACILITIES

Study	Description of Study	Findings
Report of Department of Defense (DOD) Working Group on Engineering and Science Education. Prepared by DOD-University Forum (1983)	Working group report on condition and needs of academic science and engineering	Deficiencies in research facilities and equipment acute in most universities
"Report on NIH Experience with Extramural Construction Authority" Prepared by Office of Program Planning and Evaluation, NIH (1983)	Historical comparison of legislative authorities for construction of health research facilities analyzing past facilities funding experiences	-Funding authorities mainly for special, not general, use -Almost all funds made available under grant mechanisms -Recent authorities fail to separate funds for construction and research -None of funding authorities based on systematic analysis of need
"University Research Facilities: Report on a Survey Among National Science Foundation Grantees" Conducted by Division of Policy Research and Analysis, NSF, for Infrastructure Task Group of National Science Board (NSB) (June, 1984)	Survey of 1983 NSF grant Principal Investigators (248 investigators randomly sampled) to determine condition of existing facilities and the impact of facilities on research	-70% facilities had been renovated in last 10 years using 7% Federal $ -50% facilities slated for renovation in next three years -80% of P.I.'s rated safety of facilities as excellent -60% reported having lost some research time in past year due to facilities-related failures; 40% reported graduate students had spent 3 or more days fixing problems created by facilities over past year

STUDIES OF ACADEMIC FACILITIES

Study	Description of Study	Findings
Proposed study of cancer research facilities Conducted by President's Cancer Panel and the National Cancer Institute (Proposed)	Proposed survey study to gather data to inventory the quality and quantity of current research facilities in cancer research	In progress
Facilities Needs in Chemical Science and Engineering Conducted under aegis of the Board on Chemical Science and Technology, National Research Council (In progress)	Survey to ascertain specific facilities data for research and teaching in chemistry, biochemistry, and chemical engineering academic departments	In progress

APPENDIX 3

Financing and Managing University Research Equipment

Association of American Universities
National Association of State Universities
and Land-Grant Colleges
Council on Governmental Relations

Washington, D.C. 1985

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and management of research equipment. Milton Goldberg prepared the analysis of federal regulatory issues. Michael Goldstein of Dow, Lohnes, and Albertson drafted material on the state role in acquiring and managing research equipment. The chapters on debt financing and private support of academic research equipment are based on a background paper prepared for the Steering Committee by Coopers & Lybrand.

As our work progressed, members of the Steering Committee critically reviewed drafts of the report chapters, all of which were then discussed at committee meetings. We also benefited from the thoughtful reviews and substantive contributions to the report by Robert Clodius and John Crowley.

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Richard A. Zdanis, Chairman
Steering Committee

Patricia Warren, Project Manager

Summary and Recommendations

Contemporary science and technology are inconceivable without the array of instruments and other research equipment available today. Recent years, however, have seen steady erosion of our universities' ability to acquire and maintain equipment that qualifies as state of the art--the best generally available. Without this new equipment, advances in many scientific disciplines cannot occur. The situation has reached the point where it threatens the strength of the nation's research enterprise and the quality of education of new scientists and engineers.

The project summarized here was designed to seek ways to ensure that the funds available for scientific equipment in universities are used at maximum efficiency. We examined federal and state regulations and practices, management practices in universities, and sources and mechanisms of funding. We reached the following broad conclusions:

Many actions can be taken that clearly would enhance efficiency in the acquisition, management, and use of research equipment by universities, and they are specified in our recommendations. The overall problem is so large, however, that it cannot be properly addressed without substantial, sustained investment by all sources—federal and state governments, universities, and the private sector.

SOURCE OF THE PROBLEM

The situation has been documented in a succession of studies dating from the early 1970s. The most recent and most comprehensive study is the National Science Foundation's National Survey of Academic Research Instruments, covering the years 1982-1983. Newly published results of the survey show in part that:

- Of the university department heads surveyed, 72 percent reported that lack of equipment was preventing critical experiments.
- Universities' inventories of scientific equipment showed that 20 percent was obsolete and no longer used in research.
- Of all instrument systems in use in research, 22 percent were more than 10 years old.
- Only 52 percent of instruments in use were reported to be in excellent working condition.
- Of university department heads surveyed, 49 percent rated the quality of instrument-support services (machine shop, electronics shop, etc.) as insufficient or nonexistent.

Contributory Trends

Such difficulties stem from several interrelated trends. As scientific instruments have grown steadily more powerful and productive, their initial costs have significantly outpaced the general rate of inflation. One industrial laboratory, for example, found that the cost of keeping its stock of research equipment at the state of the art rose 16.4 percent per year during 1975-1981, while the consumer price index rose 9.9 percent per year. The growing capabilities of equipment also entail higher costs for operation and maintenance. The rapid pace of development, moreover, has shortened the technologically useful life of equipment; instruments today may be superseded by more advanced models in five years or less. And for more than 15 years, the funds available from all sources have failed consistently to reflect the rising costs and declining useful lifetimes of academic research equipment.

Research project grants, the leading source of academic research equipment, have only slightly outpaced inflation in recent years. Individual grants averaged about $94,000 at the National Science Foundation (NSF) in 1985 and $133,000 at the National Institutes of Health (NIH). Such grants can accommodate instruments of only modest cost. Benchtop equipment priced at $50,000 or more is common, however, and research in a number of fields is relying increasingly on equipment that costs from $100,000 to $1 million.

Trends in funding of scientific equipment in universities have long been dominated by federal spending, which accounted for 54 percent of the equipment in use in 1982-1983; the universities themselves are the next most important source of support and provided 32 percent of such funding. States directly funded 5 percent of the cost of the equipment in use in 1982-1983, individuals and nonprofit organizations funded 5 percent, and industry funded 4 percent. Federal funding of academic research--including the associated equipment--grew at an average annual rate of 15.7 percent, in constant dollars, during 1953-1967, but the rate fell to 1.6 percent during 1968-1983.

Besides its role in support of research, the government was a major contributor to the universities' massive capital expansion of the 1950s and 1960s, which included substantial amounts of scientific equipment. Again, however, the rate of federal investment turned downward. The government's annual spending on academic R&D facilities and equipment, in constant dollars, fell some 78 percent during 1966-1983.

RESPONSES TO THE PROBLEM

Both academic and federal officials responded to essentially level funding by supporting people over investment in capital equipment. The fraction of research-project support allocated to permanent university equipment by the National Institutes of Health declined from 11.7 percent in 1966 to an estimated 3.1 percent in 1985. At the National Science Foundation the fraction fell from 11.2 percent in 1966 to an average of 7.1 percent during 1969-1976. The federal mission agencies' support for research equipment declined similarly, although exact data are not available.

Efforts to ease the universities' serious difficulties with scientific equipment began to appear in the early 1980s. NSF increased its investment in academic equipment from 11 percent of its university R&D budget in 1978 to an estimated 17.5 percent in 1985. The Department of Defense launched a special five-year university instrumentation program, totaling $150 million, which is projected to run through 1987. The Department of Energy began a special $30 million program scheduled to end in 1988. The federal and state governments adopted tax incentives designed to encourage contributions of equipment by its manufacturers. State governments began to increase their funding of equipment for state colleges and universities and have initiated a range of development activities designed in part to attract industrial support for R&D in their universities.

The expanded federal investments were the result, in part, of the efforts of the Interagency Working Group on University Research Instrumentation, which was organized in mid-1981 to focus high-level agency attention on the university instrumentation problem. Its members were senior officials drawn from each of the six major agencies supporting research in universities--the National Science Foundation, the National Institutes of

Health, the National Aeronautics and Space Administration, and the Departments of Agriculture, Defense, and Energy.

BACKGROUND OF THE STUDY

Although these initiatives are welcome, they clearly are not sufficient. Officials in academe and government agree that the equipment problem is critical and steadily growing and that ways to use existing resources more efficiently must be explored. In July 1982 at the request of the Interagency Working Group, the Association of American Universities, the National Association of State Universities and Land-Grant Colleges, and the Council on Governmental Relations convened an ad hoc planning committee to consider whether a special effort was needed to address the following questions:

- Could changes be made in federal or state laws, regulations, or policies that would enhance the efficiency of acquisition, management, and use of academic research equipment?
- What more can universities do to improve the way they acquire, manage, and use research equipment?
- Does debt financing hold significant untapped potential for universities as a means of acquiring new research equipment?
- Can present tax incentives for the donation of research equipment to universities be revised to increase support from industry?
- Are there alternative methods of direct federal funding of research equipment that would yield a better return on the federal investment?

The resulting analysis was carried out jointly by the three associations with funding from the six federal agencies and the Research Corporation. Substantive direction for the study was provided by a seven-member Steering Committee chaired by Richard Zdanis, Vice Provost of Johns Hopkins University. Much of the field research was done by a three-member team: Robert Bock, Dean of the Graduate School at the University of Wisconsin; David Litster, Director of the Center for Materials Science and Engineering at MIT; and Julie Norris, Assistant Provost of the University of Houston. This team visited 23 universities and governmental and industrial laboratories; they met with more than 500 faculty investigators, department chairmen, research and service center directors, deans and chief administrators, or the functional equivalents in government and industry. (A list of the places visited is appended to this summary.) The team and the firm of Coopers & Lybrand each produced background reports for the project.

RECOMMENDATIONS

The actions recommended below, as we stated at the outset, would clearly enhance efficiency in the acquisition, management, and use of academic research equipment. We would like to emphasize, however, that even if all these recommendations are acted upon, the universities' equipment needs are so large that they cannot be met without substantial increases in funding. Modernization, moreover, cannot be a one-time effort. Continuing investment will be required based on the recognition that laboratories in many fields of science have to be reequipped at intervals of five years or less. The universities, the states, and industry must share with the federal government the responsibility for modernization and long-term maintenance of the quality of scientific equipment at the nation's universities.

The recommendations that follow appear in the topical order employed in the full report: the federal government, the states, the universities, debt financing by universities, and private support for equipment.

The Federal Government

The federal government has been the major funder of research equipment in universities during the past four decades. Current federal funding mechanisms, however, do not comprise adequate means of regularly replacing obsolete or worn-out equipment with state-of-the-art equipment. Regulatory and procedural difficulties complicate the problem.

We recommend...

1. **That the heads of federal agencies supporting university research issue policy statements aimed at removing barriers to the efficient acquisition, management, and use of academic research equipment.** Few federal regulations, as written, contribute directly to the equipment problem. Inconsistent interpretation of regulations by federal officials, however, complicates the purchase, management, and replacement of research equipment and leads to unnecessarily conservative management practices at universities. Desirable actions are summarized in the recommendations below.

2. **That federal agencies more adequately recognize and provide for the full costs of equipment, including operation and maintenance, space renovation, service contracts, and technical support by...**

...providing these costs in project grants and contracts or ensuring that recipients have provided them.

...accepting universities' payment of costs such as installation, operation, and maintenance as matching funds on programs that require matching contributions by universities.

3. **That federal agencies adopt procedures that facilitate spreading the cost of more expensive equipment charged directly to research-project awards over several award-years and allow the cost and use of equipment to be shared across award and agency lines.** Individual research-project grants and contracts normally can accommodate equipment of only modest cost. Investigators, moreover, have difficulty combining funds from awards from the same or different agencies to buy equipment.

4. **That federal auditors permit universities to recover the full cost of nonfederally funded equipment from federal awards when they convert from use allowance to depreciation.** Office of Management and Budget (OMB) Circular A-21 permits such conversion as well as recovery of full cost. Auditors of the Department of Health and Human Services, however, permit recovery only as if the equipment were being depreciated during the time it was in fact covered by the use allowance. This practice, in effect, denies recovery of full cost.

5. **That the Office of Management and Budget make interest on equipment funds borrowed externally by universities unequivocally an allowable cost by removing from OMB Circular A-21 the requirement that agencies must approve such charges.** Interest on externally borrowed funds has been a permissible cost since 1982 at the discretion of the funding agency, but agencies have shown significant reluctance to permit it. The perception of inability to recover interest costs may lead university officials to decide against seeking debt financing for equipment.

6. **That all federal agencies vest title to research equipment in universities uniformly upon acquisition, whether under grants or contracts.** Federal regulations on title to equipment vary among agencies, and such variability inhibits efficient acquisition, management, and use of equipment. Without assurance of title, for example, investigators hesitate to combine university funds with federal funds to acquire an instrument not affordable by a single sponsor.

7. **That the Office of Management and Budget make federal regulations and practices governing management of equipment less cumbersome by...**

...setting at $10,000 the minimum level at which universities must screen their inventories before buying new equipment and, above that minimum, permitting universities and agencies to negotiate different screening levels for different circumstances.

...raising the capitalization level for research equipment to $1,000 in OMB Circulars A-21 (now at $500) and A-110 (now at $300) and giving universities the option of capitalizing at different levels.

8. **That the Department of Defense eliminate its requirement that the inventory of the Defense Industrial Plant Equipment Center (DIPEC) be screened for the availability of specialized scientific equipment requested by universities before new equipment is purchased.** The descriptions of equipment in the DIPEC inventory do not permit a federal property officer to determine whether a scientific instrument in the inventory is an adequate substitute for the one requested. Hence, the requirement for screening is wasteful for both universities and the government.

9. **That other federal agencies adopt the NIH and NSF prior approval systems.** Purchases of equipment with federal funds ordinarily must be approved in advance by the sponsoring agency. Purchases can be approved by the university, however, under the NIH Institutional Prior Approval System and the NSF Organizational Prior Approval System. These systems markedly improve speed and flexibility in acquiring equipment.

The States

State governments act as both funder and regulator in regard to academic research equipment, and conflict between these roles is inherent to a degree in the relationship between the states and their public universities. Still, we believe that in many cases the states could combine these broad roles more rationally and could otherwise help to ease the schools' difficulties with research equipment.

We recommend...

1. **That states assess the adequacy of their direct support for scientific equipment in their public and private universities and colleges relative to support from other sources and the stature of their schools in the sciences and engineering.** The states cannot displace the federal government as the major funder of academic research equipment, but judicious increases on a highly selective basis could be extremely beneficial to the scientific stature of states while simultaneously increasing the effectiveness of funds available from federal and industrial sources.

2. **That states grant their public universities and colleges greater flexibility in handling funds.** Desirable provisions would permit schools to transfer funds among budget categories, for example, and to carry funds forward from one fiscal period to the

next. Greater flexibility would not only improve the universities' ability to deal with the problems of research equipment, it would also be likely to provide direct savings in purchasing and would free academic administrators to discharge their responsibilities more efficiently.

3. **That states examine the use of their taxing powers to foster academic research and modernization of research equipment.** Tax benefits available under the federal Internal Revenue Code are also available in 34 states whose tax codes automatically follow the federal code. Relatively few states, however, have adopted tax benefits designed to fit their particular circumstances.

4. **That states revise their controls on procurement to recognize the unusual nature of scientific equipment and its importance to the research capability of universities.** Scientific equipment often is highly specialized. Instruments that have the same general specifications but are made by different vendors, for example, may have significantly different capabilities. The differences, furthermore, may be discernible only by experts in the use of the equipment. Desirable revisions in state controls would exempt research equipment from purchasing requirements designed for generic equipment and supplies, such as batteries and cleaning materials; would vest purchasing authority for research equipment in individual colleges and universities; and would not apply rules beyond those already mandated by the federal government.

5. **That states consider revising their controls on debt financing of scientific equipment at public colleges and universities to permit debt financing of equipment not part of construction projects, recognize the relatively short useful life of scientific instruments, and relieve the one- and two-year limits on the duration of leases.**

The Universities

The universities' ability to acquire and manage research equipment efficiently is affected by their individual circumstances, their traditionally decentralized authority, the individual project-award system that funds much of the equipment, and state and federal regulations. Within this context, however, we have identified a number of management practices that warrant more widespread use.

Our findings indicate that universities would benefit from stronger efforts to improve their internal communications. Moreover, our recommendations on the whole imply a need for a more centralized approach than is now the general practice in universities' management of research equipment. We note that other developments, including the universities' growing interest in debt financing and strategic planning, also point toward more centralized management.

We recommend...

1. **That universities more systematically plan their allocation of resources to favor research and equipment in areas that offer the best opportunities to achieve distinction.** Such strategic planning should involve participation by both administrators and faculty. The process may well call for hard decisions, but we believe that they must be made to optimize the use of available funds.

2. **That universities budget realistically for the costs of operating and maintaining research equipment.** These costs impose serious and pervasive problems, and failure to plan adequately for full costs when buying equipment is widespread as well. Full costs include not only operation and maintenance, but space renovation, service contracts, technical support, and the like. Maintenance is particularly troublesome. Hourly user charges are commonly assessed to cover the salaries of support personnel and the costs of maintenance, but are difficult to set optimally and are rarely adequate.

3. **That investigators and administrators at universities seek agency approval to spread the cost of expensive equipment charged directly to research-project awards over several award years.** As noted in Recommendation 3 under the Federal Government, individual research grants and contracts cannot normally accommodate costly equipment, and this problem would be eased by spreading costs over several years.

4. **That universities act to minimize delays and other problems resulting from procurement procedures associated with the acquisition of research equipment.** To be most effective, the procurement process should be adapted to the specialized nature of research equipment, as opposed to more generic products. Similarly, specialized purchasing entities or individuals would facilitate timely acquisition of equipment at optimum cost. Also beneficial would be formal programs designed to inform purchasing personnel and investigators of the needs and problems of each.

5. **That universities consider establishing inventory systems that facilitate sharing.** One such system is the basis of the research equipment assistance program (REAP) at Iowa State University. The REAP inventory includes only research equipment. REAP may not be cost effective for all universities, but most should find elements of it useful.

6. **That universities use depreciation rather than a use allowance to generate funds for replacing equipment, providing that**

they can negotiate realistic depreciation schedules and dedicate the funds recovered to equipment. Universities can use either method, but rates of depreciation are potentially higher--and so recover costs more rapidly--than the use allowance (6 2/3 percent per year) because they can be based on the useful life of the equipment. Both methods, however, add to indirect costs, and neither can be used for equipment purchased with federal funds.

7. **That universities seek better ways to facilitate the transfer of research equipment from investigators or laboratories that no longer need it to those that could use it.** Faculty at most schools have no incentive to transfer equipment, excepting the need for space, and every incentive to keep it in case it might be needed again. Some systematic mechanism for keeping faculty well informed of needs and availability of equipment would be useful.

Debt Financing of Research Equipment

Universities traditionally have used tax-exempt debt financing to pay for major facilities and lately have been using the method to some extent to buy research equipment. A number of financing methods can be adapted to the special characteristics of such equipment, but whatever the method, such financing competes with other university needs for debt. Debt financing imposes risk on the university as a whole, and so implies a shift from decentralized toward centralized authority.

We recommend...

1. **That universities explore greater use of debt financing as a means of acquiring research equipment, but with careful regard for the long-term consequences.** Universities vary widely in their use of debt financing, but a universal concern is the need for a reliable stream of income to make the debt payments. It should also be recognized that the necessary commitment of institutional resources, regardless of the purpose of the debt financing, erodes the university's control of its future, in part by reducing the flexibility to pursue promising new opportunities as they arise. Debt financing also increases the overall cost of research equipment to both universities and sponsors of research.

2. **That universities that have not done so develop expertise on leasing and debt financing of equipment.** This expertise should include the ability to determine and communicate the true costs of debt financing and should be readily accessible to research administrators and principal investigators. The increasing complexity of tax-exempt debt financing, the many participants,

the necessary legal opinions, and the various political and/or corporate entities associated with debt financing make it essential that universities fully understand the marketplace.

Private Support

The effects of the Economic Recovery Tax Act (ERTA) of 1981 on corporate spending on R&D and corporate contributions of research equipment to universities are not clear, for several reasons: the act has been in effect only since August 1981, its effects are entangled with other economic variables in a complex manner, and the uncertain future of the R&D tax credit, which is scheduled to expire at the end of 1985, may have skewed corporate response to it (the equipment donation provision is permanent). Nevertheless, the consensus appears to be that ERTA, suitably modified, should indeed spur technology, in part by fostering support for academic research and scientific equipment. We agree with this view.

We recommend...

1. **That industry take greater advantage of the tax benefits provided by the Economic Recovery Tax Act (ERTA) of 1981 for companies that donate research equipment to universities and fund academic research.** Universities' experiences with industry indicate that company officials may not be fully aware of the benefits available, although company tax specialists generally are well informed.

2. **That universities seek donations of research equipment more aggressively by developing strategies that rely in part on the tax benefits available to donors.** Sound strategies would stress both federal and state tax benefits as well as other important benefits to both donor and recipient.

3. **That Congress modify ERTA so that...**

...equipment qualified for the charitable donation deduction include computer software, equipment maintenance contracts and spare parts, equipment in which the cost of parts not made by the donor exceeds 50 percent of the donor's costs in the equipment, and used equipment that is less than three years old. Computers are properly viewed as computing systems, which are incomplete without software. Maintenance of scientific equipment is costly to the point where universities have declined donations of equipment because they could not afford to maintain it. Makers of sophisticated equipment rely primarily on their technological knowledge, not their ability to make parts. Thus the limit on parts from outside suppliers is unrealistic, provided that the manufacturer is in fact in the business of developing and making scientific equipment.

...the provisions on the R&D tax credit are made permanent, with revision to create an additional incentive for companies to support basic research in universities. Equipment acquired under research contracts qualifies for the credit, but ERTA currently provides the same incentive for companies to contract for research in academe as for research by other qualified organizations.

...the social and behavioral sciences are made qualified fields of academic research in terms of the equipment donation deduction and the R&D tax credit. The social and behavioral sciences contribute to the application and utilization of science and technology, and they rely increasingly on research instrumentation.

...qualified recipients of equipment donations and R&D funding, in terms of ERTA tax credits, include research foundations that are affiliated with universities but remain separate entities. Some state universities have established such foundations to receive and dispose of donated equipment because they cannot dispose of it themselves without legislative consent.

These actions, we are convinced, would yield material benefits in the acquisition and management of research equipment by universities. The rationale for them here is necessarily brief. Much fuller background will be found in the five chapters of the full report, where these recommendations also appear.

Site Visits

UNIVERSITIES

Public:	Colorado State University Georgia Institute of Technology Iowa State University North Carolina State University Texas A&M University University of Illinois, Urbana University of Minnesota University of New Mexico University of North Carolina, Chapel Hill University of Texas, Austin University of Virginia
Private :	Carnegie-Mellon University Columbia University Duke University Harvard University Massachusetts Institute of Technology Princeton University Rice University Stanford University University of Chicago University of Delaware University of Pennsylvania Washington University, St. Louis

CORPORATE LABS

Beckman Instruments, Inc.
Dupont
Hewlett-Packard
Honeywell
Microelectronics Center of North Carolina
Syntex Research

GOVERNMENT LABS

Los Alamos National Laboratory
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1

Academic Research Equipment: The Federal Role

BACKGROUND AND TRENDS

The federal government has been the major funder of research and development and the associated equipment in U.S. universities during the four decades following World War II. The government has always recognized the utility of science and technology, but, except for agricultural research, funded relatively little research in universities before 1940.[1] The massive postwar commitment sprang from the success of science in the war effort and its consequent promise for the well-being of the nation in peacetime. Federal funding of academic research drew further impetus from the launching of Sputnik 1, the first earth-orbiting satellite, by the Soviet Union in October 1957. The federal commitment is by now well established, although the rate of increase of funding declined sharply after the late 1960s.

The government supports the acquisition and operation of research equipment in universities in a number of ways. These support mechanisms are implemented by federal regulations and agency guidelines designed to ensure accountability for the public funds expended and proper use of equipment. The regulations are administered by the sponsoring agencies and the universities. The universities' compliance with the regulations is monitored by the Audit Agency of the Department of Health and Human Services, which handles about 95 percent of all colleges and universities, and the Defense Contract Audit Agency in the Department of Defense. The regulatory structure in some measure inhibits the universities' freedom of action, but the importance of federal funds to research and graduate education causes both partners to search for accommodations.

Funding Trends

Federal funding of academic research and development is the best available indicator of trends in federal funding of academic research equipment (trend data specific to equipment do not exist). In constant 1972 dollars, federal funding grew at an average annual rate of 15.7 percent during 1953-1967 and 1.6 percent during 1968-1983 (Figure 1 and Appendix A). Federal funding in current dollars was $4.96 billion in 1983, when it comprised 64 percent of total spending for academic R&D (Figure 2); state and local governments accounted for 7 percent, industry for 5 percent, the universities themselves for 16 percent, and all other sources for 8 percent.

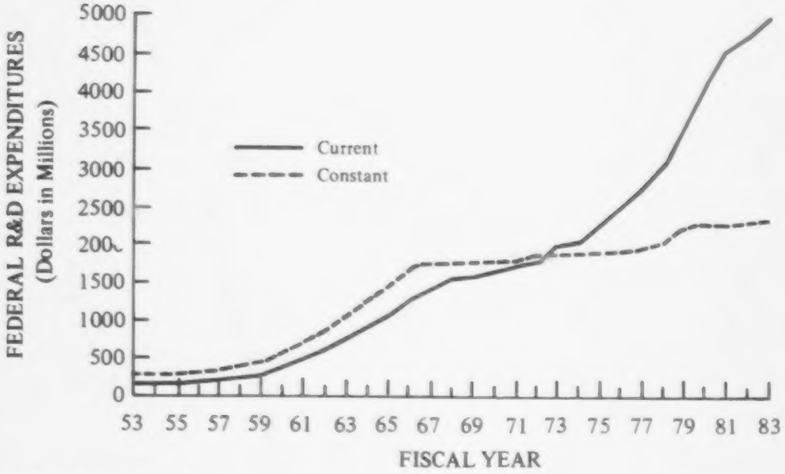
Recent data on research equipment alone show a similar pattern. The federal government accounted for 65 percent of total spending for academic research equipment in 1982 and 63 percent in 1983. Nonfederal sources of funding increased by 14.5 percent between 1982 and 1983, while federal funding of academic research equipment grew by only 2.4 percent (Appendix B).

A significant source of research equipment was the building boom of the 1960s in academic R&D facilities. The institutions had been expanding since the early 1950s in response to a national need to cope with the postwar growth in enrollments. The launching of Sputnik led the federal government to invest heavily in expanding their capacity for graduate education and research in the sciences and engineering. The boom tapered off in the late 1960s. Spending on academic R&D facilities and equipment, currently about $1 billion per year, has been relatively flat since 1968 in current dollars and, in constant dollars, declined 78 percent during 1966-1983 (Figure 3). The federal share of the total, meanwhile, declined from 32 percent in 1966-1968 to 12 percent in 1983. Federal obligations for academic R&D plant have been relatively flat since 1973 in current dollars, averaging about $38 million per year (Figure 4); in constant dollars the obligations fell 93 percent during 1966-1983 and 64 percent during 1973-1983.

The Equipment Problem

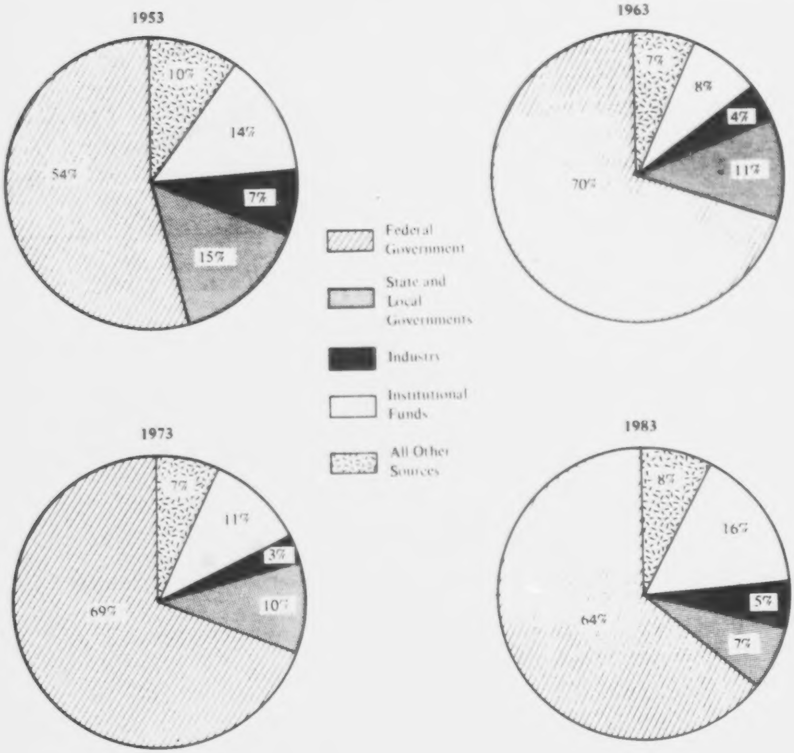
The trends of the past 15 years or so in federal funding of academic R&D and facilities are significant elements of the universities' serious problem with research equipment. The problem is usually stated as a shortage of state-of-the-art equipment, but the costs of operation and maintenance are serious difficulties as well.

FIGURE 1
Federal R&D Expenditures at Universities and Colleges
Fiscal Years 1953-1983



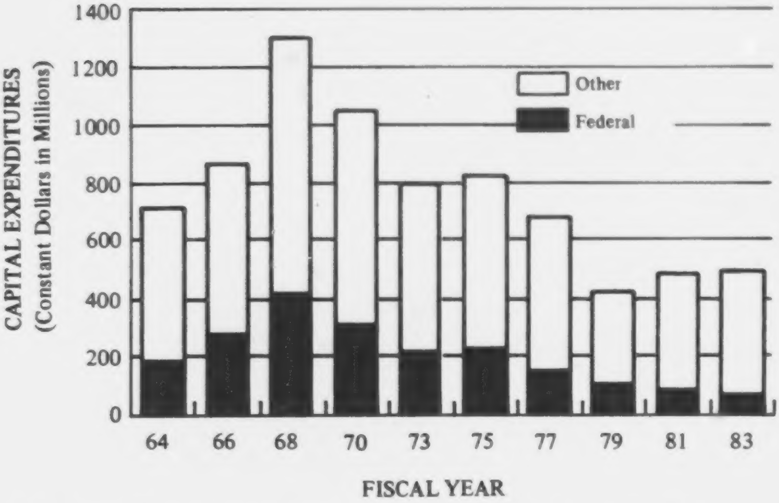
SOURCE: Appendix A.

FIGURE 2
Percentage of Total R&D Expenditures at Universities and Colleges by Source



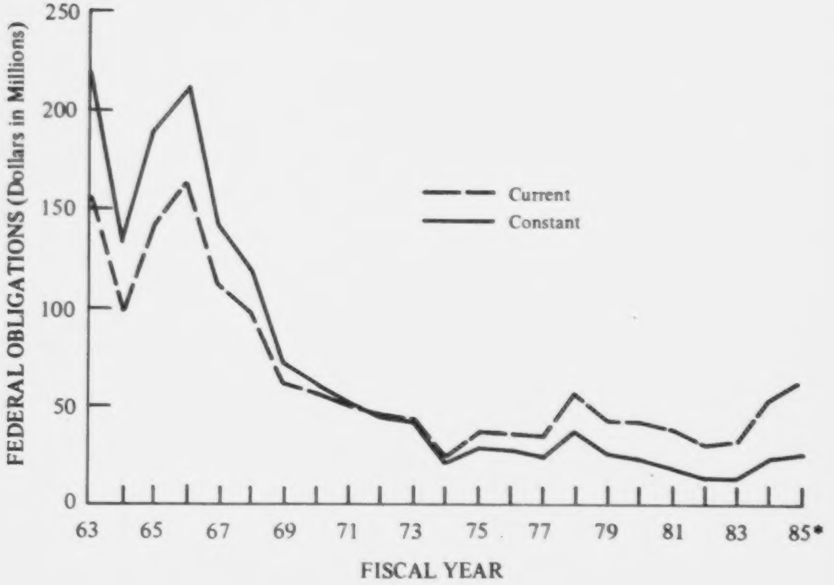
SOURCE: Appendix A.

FIGURE 3
Capital Expenditures for Academic Scientific and Engineering Facilities and Equipment for Research, Development, and Instruction
Fiscal Years 1964-1983



SOURCE: Division of Science Resources Studies, National Science Foundation.

FIGURE 4
Federal Obligations for R&D Plant to
Universities and Colleges
Fiscal Years 1963-1985



SOURCE: Division of Science Resources Studies, National Science Foundation.
NOTE: Figures for 1984 and 1985 are estimates.*

The situation has been examined in studies that date back to 1971.[2-8] These studies give only crude estimates of the cost of updating academic research equipment nationwide,[9] but the reality of the problem is not in question. According to the National Science Foundation (NSF) National Survey of Academic Research Instruments, 72 percent of department heads reported in 1982-1983 that lack of equipment was preventing critical experiments. NSF grantees in a second study were asked to rank six factors for importance in spending university money to improve research.[10] They ranked instrumentation first more often than any other factor and facilities second. The other factors were numbers of positions and pay for faculty and for graduate students.

The remarkable power of modern scientific instruments, ironically, is part of the problem—as equipment has grown steadily more sophisticated, its cost has outrun the overall rate of inflation. The most powerful versions of some kinds of equipment, moreover, now cost so much that the government funds them only for use in national or regional facilities as opposed to exclusive use by one university or one investigator. The trend is evident in a major industrial laboratory's comparison of the cost of sustaining state of the art in equipment in 1975 and 1981.[11] The study was based on 126 items of equipment worth some $13.5 million in 1981. Costs were found to have climbed 16.4 percent per year during 1975-1981; the consumer price index during the same period rose 9.9 percent per year.

Start-Up Costs

The rapid evolution of equipment in power and cost has especially affected start-up costs for faculty investigators. A midwestern university, for example, equipped two new investigators with comparable experience and interests in chemistry, one in 1970 and one in 1979.[12] The investigator equipped in 1970 needed dedicated equipment costing $8,000 and access to departmental equipment costing $116,500. For the investigator equipped in 1979, these figures had climbed to $43,850 and $741,000, equivalent to an annual increase of 22 percent for laboratory instruments and 23 percent for departmental instruments. Without the costlier, more powerful equipment, however, the investigator equipped in 1979 would not have realized his potential in contributing to his field of research.

The experience was typical of the 1970s, and the costs have continued to rise in the 1980s. Chemistry and other fields where investigators traditionally work with personal, bench-top equipment have become capital intensive. The cost of equipment and facilities needed for a new faculty member today may easily surpass the size of the endowment needed to pay his salary.[13]

People Versus Equipment

During this period of rising costs for research equipment, federal funding agencies have displayed growing reluctance to pay for it at the expense of the operating costs of research. The usual preference is to fund people at the expense of equipment. The fraction of research-project support allocated to permanent laboratory equipment by the National Institutes of Health (NIH) declined from 11.7 percent in 1966 to an estimated 3.1 percent in 1985. At NSF, the fraction fell from 11.2 percent in 1966 to an average of 7.1 percent during 1969-1976. During the past few years, however, the agencies have been paying more attention to equipment (see below). NSF support, for example, is expected to rise to an estimated 17.5 percent of total research-project support for fiscal year 1985.

FUNDING MECHANISMS

Federal funds for academic research equipment for some years have largely been built into the support for the work in which the equipment is to be used. An investigator's research proposal, for example, may request funds for new equipment needed as well as for the research itself. Several agencies recently have started direct funding programs specifically for equipment in response to the universities' growing problem with it. Nevertheless, the diverse array of traditional funding mechanisms remains the leading source of federal support for academic research equipment. These mechanisms have contributed immensely to the strength of U.S. science. Some of their characteristics, and the associated regulations, however, tend to complicate the acquisition, operation, and maintenance of equipment.[14]

Individual Research Projects

Almost half of federal support for research in universities comprises grants or contracts for individual research projects to be conducted by one or a few investigators. Awards are made on the basis of proposals submitted by investigators and evaluated as a rule by scientific and technical review. Proposals are judged comparatively as well as on their own merits. This competitive approach is designed to ensure that the available funds support the most worthy research. Currently, a proposal has a 30 to 50 percent chance of succeeding.*

Research-project grants and contracts are awarded to the investigator's university. The term is rarely more than three years, and the amount rarely exceeds $200,000 per year. Project grants awarded by NIH in 1985, for example, averaged $133,000; at NSF they averaged about $94,000 (Figure 5). The amounts of the awards generally have kept up with inflation, but research itself has become more capital intensive, and that capital expense is often reflected in university investment in equipment and facilities.[13]

The strengths and weaknesses of the research-project system have been studied at length.[14] The size of the awards, for example, permits many investigators to be supported and many agencies to fund research of interest to them. On the other hand, the number and relatively short terms of awards create a heavy administrative task for agencies, universities, and researchers. Active scientists may need three or four grants to support their programs and so devote much time to competing for funds from federal and other sources.

As the costs of equipment have outpaced inflation, project awards increasingly have accommodated equipment of only modest cost. Funds generally cannot be carried forward or backward between grant years to acquire equipment too costly to buy from one year's funds. Further, individual scientists have difficulty combining funds from more than one award to acquire equipment; similarly, several scientists usually find it difficult to pool funds from their awards for equipment to be shared. Also, the rising costs of equipment have led agencies to increase their requirements for matching funds from universities (see further discussion in regulatory section below).

A Major Barrier

The mismatch between the size of individual research grants and the costs of much research equipment would be eased significantly by permitting equipment to be purchased in the initial grant-year with payment spread over the subsequent two to four years as a direct charge. The lack of such a systematic approach

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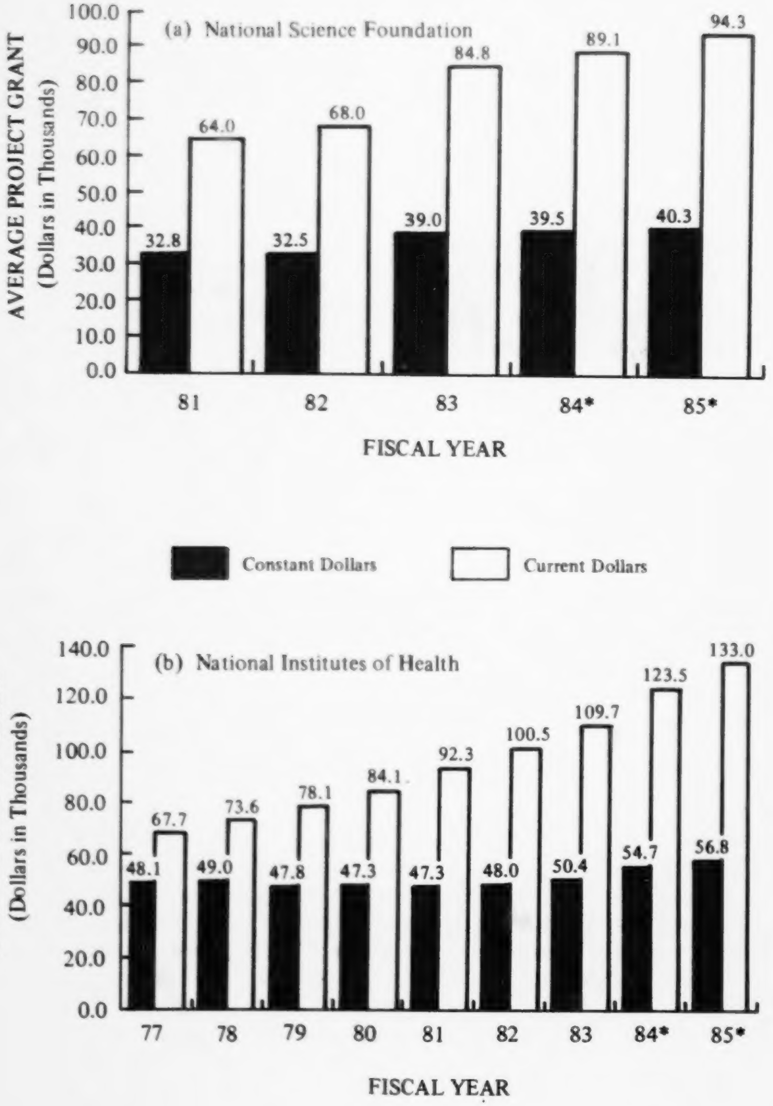
*In 1975, NIH received 12,160 grant applications; 46 percent were actually funded. In 1983, applications totaled 19,154, of which only 33 percent were funded.[15]

FIGURE 5
Average Project Grant Size



SOURCE: National Science Foundation, National Institutes of Health.
NOTE: Figures for 1984 and 1985 are estimates.*

to acquiring equipment is a major barrier to acquisition. Our conversations with chief business officers of universities revealed that most would be willing to finance or arrange for financing of research equipment if repayment, including interest, could be charged directly to grants over several years.

The indirect cost mechanism is not satisfactory to encourage equipment acquisition, because indirect costs are seldom fully recovered. Additionally, rising indirect cost rates are being attacked by the government, the Congress, and university faculty members. Increased indirect cost rates, even for equipment purchases, receive little understanding or support.

This dilemma leaves many investigators searching for ways to acquire equipment directly that entail "reasonable" financing costs. Some such mechanisms are described in Chapter 4.

Experiments with Grants

A full critique of the research-project system is beyond the scope of this report. We note, however, that the flaws in the system affect not only equipment. The administrative burden was cited above. More broadly, the emphasis on discrete tasks of relatively short duration restricts the flexibility of universities and their scientists in handling funds and pursuing research in terms of long-range, coherent programs. Federal agencies are struggling with such problems. NIH is experimenting with grants of five years or more.[15] Such grants were common at one time, but maximum award periods gradually shrank to the now-common three years during the 1970s. One of the new NIH experimental programs, the Outstanding Investigator Grant of the National Cancer Institute, is a seven-year award that will permit funds to be carried over from one year to the next.

Research Programs

Research programs funded by federal agencies involve broad, coherent areas of investigation and more than one investigator. Annual support generally exceeds $200,000. One example of a research program is a Department of Energy (DOE) grant to a university for research by a group of investigators in high-energy particle physics. Although research programs are larger than individual projects, the strengths and weaknesses of the two mechanisms are similar.

Research Centers

Federal agencies also support research centers—academic organizations that work in broad fields of research of interest to the university and the sponsoring agency. Examples include the NIH Categorical Disease Centers and the NSF Materials Research Laboratories. Research centers receive block (core) funding, as contrasted with individual project funding. Management of the center and coordination of specific research projects into a coherent program are delegated to the university. Proposals for specific research projects must be approved there, but may or may not be reviewed and approved individually by the sponsoring agency.

Our study team visited four of the 14 Materials Research Laboratories (MRLs) supported by NSF. The MRLs receive five-year block grants that support multi-investigator research on materials as well as central facilities with equipment costing in the range of $100,000 to $1 million. Block funding unquestionably eases equipment problems; the scientists we spoke with considered themselves relatively well equipped in relation to colleagues at many other universities.

A thorough study of materials research conducted at MRLs and at other universities with project-grant support was completed in 1978.[16] The results showed in part that the MRL core-grant mechanism was more efficient than project-grant funding in terms of time and money expended by NSF and the university in administering grants. The MRLs also were found to be scientifically effective. In terms of both efficiency and quality of research, however, core funding was not found to be clearly superior to other funding mechanisms examined. The results did suggest that different funding mechanisms lead to different ways of doing research and produce different kinds of science.[14]

NSF currently is starting a major new program of block-funded, multidisciplinary engineering research centers at universities.[17] The invitation to submit proposals drew 142 responses involving 3,000 investigators at 107 universities. One of the attractions of the program is the opportunity to obtain state-of-the-art equipment. Eight universities have been selected to start six of the centers in 1985. The six will receive $94.5 million from NSF over the next five years and are expected to attract additional funds from industry. As many as 20 of the centers may be established eventually. NSF plans also to spend $200 million over the next five years to set up supercomputer research centers at the University of California at San Diego, the University of Illinois at Urbana-Champaign, Cornell University, and the John Von Neumann Center near Princeton.[18]

Large Facilities

Federal agencies support a number of national and regional facilities based on equipment deemed too costly to be dedicated to use at one university. These large facilities, like research centers, receive block funding. They are designed to give academic scientists, on a national or regional basis, access to instruments that would not otherwise be available to them. Examples include the Stanford Synchrotron Radiation Laboratory (SSRL) supported by DOE and the regional instrumentation centers supported by NSF.

Large facilities serving many users predictably face problems peculiar to that mode of operation (see discussion of National and Regional Facilities in Chapter 3). For example, instruments commited to a broad range of users cannot also be modified to meet highly specialized needs. Large centers can provide only limited access to the instrumentation, causing delays in research. Costs of travel and lodging are rising sharply, and centers are sometimes geographically isolated from universities. At national facilities, with equipment costing millions of dollars, the only realistic option is to find ways to minimize the problems. The cost of equipment at regional facilities, on the other hand, may not absolutely bar providing it for one university, providing that the equipment is utilized fully and effectively. Resolution of such issues requires an evaluation of costs versus scientific effectiveness, such as the study of the NSF Materials Research Laboratories cited above.

General Research Support

Federal agencies provide general research support to universities to strengthen their research capabilities or for work in a specified subject area. The recipient has considerable discretion in the use of the funds. Such support is provided today only by the U.S. Department of Agriculture (USDA), through funding of Agricultural Experiment Stations under the Hatch Act and related programs, and by NIH in its Biomedical Research Support Grants. The experiment stations are attached to land-grant universities and have a relatively free hand in deciding the specific research to be undertaken so long as it is agricultural research.

The NIH Biomedical Research Support Grant (BRSG) provides institutional support based on NIH-funded research at the university. The grant is thus indirectly subject to scientific and technical review. The funding ceiling for the BRSG program is set by statute at 15 percent of total NIH appropriations for research grants. The percentage actually awarded declined from an average of almost 8 percent in the late 1960s to 1.5 percent in fiscal year 1984. BRSG awards totaled $47.4 million in 1984 and were distributed among 546 institutions.

We found that BRSG awards are highly regarded in academe because of the local discretion permitted in the use of the funds. Research equipment benefits markedly from these awards. A recent assessment shows that 25 percent of the BRSG funds spent at nine universities in 1979-1980 contributed to the purchase or maintenance of central research facilities including equipment.[19] In fiscal year 1982, BRSG awards totaling about $44 million were distributed among 516 institutions; of the total, $6.4 million, or 14.5 percent, was spent by universities on shared equipment or instruments.

NSF had a similar program from 1961 to 1974. The Institutional Grants for Science were based on all federal support for scientific research received by a university except support from the Public Health Service (mainly NIH). Obligations for these grants peaked at $15.2 million in 1967. During the 14-year life of the program, more than 50 percent of the funds awarded was used to buy instrumentation.*[20]

Special Equipment Programs

Four federal agencies in recent years have been supporting special programs that provide academic research equipment separately from the normal research funding mechanisms. The Department of Defense (DOD) has a five-year program scheduled to run through 1987; DOE has a five-year program projected to run through 1988. NIH and NSF have programs with no fixed expiration dates. The four agencies' programs are designed to respond to competitive proposals. They vary, however, in characteristics and requirements; detailed descriptions are given in Appendix C.

The magnitude of the universities' equipment problem is suggested by experience with the DOD program, which is funded at $30 million per year. For the first year of the program, fiscal year 1983, the agency received 2,500 proposals for instrumentation valued at a total of $645 million. Two hundred proposals were funded. In Phase 2 (fiscal year 1984-1985) DOD received 1,870 proposals, totaling $370.1 million, and made 452 awards to 147 institutions.

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*In the same period, NSF had two other general support programs--the University Science Development Program and the Departmental Science Development Program. Both were designed to expand capacity; they were eliminated in the early 1970s when that task was judged to be completed.[14]

An important characteristic of these special equipment programs is that generally they do not pay full costs (see Appendix C). Renovation of facilities, operation and maintenance, and similar necessities are not covered. Matching funds may be required but sometimes are only encouraged. Matching contributions often cannot include the costs of operation, maintenance, and other elements of full cost. All of the universities we visited report that these excluded costs and matching requirements are serious practical concerns in decisions to compete for funding from the special equipment programs.

Despite the differences in the programs, the agencies' general approach can be illustrated by the DOE design. A level of matching funds is not specified, but matching is a factor in evaluating the applications. DOE will not pay for renovation and installation, operation and maintenance, service contracts, and technical support. The matching contribution, however, can include the costs of shipping, installation, and renovation and modification of the space for the instrument. (In fiscal year 1984, the match also could include the costs of operation and maintenance, and we are concerned by the removal of this provision in view of the heavy costs thus excluded from matching.) The university must estimate the usable life of the instrument and demonstrate plans for ensuring its continued availabiliy during the first five years.

Operations and Maintenance

Operations and maintenance are funding problems not only in special equipment programs. These functions together, over the service of life of equipment, may cost more than the purchase price. Still, funding agencies often do not cover the costs of maintenance and professional support staff for research equipment. This situation has started to change, however. The Chemistry Division at NSF, for example, now requires a university to indicate in research proposals how it will maintain equipment. We welcome this development as long as agencies recognize their obligation to meet these costs as part of their support for research.

When funding agencies' budgets are trimmed, operating and maintenance funds are vulnerable. Astronomers at one university we visited, for example, were given a computer developed several years ago for image scanning. They have been funded by NSF to adapt it to a facility for automated plate scanning but anticipate trouble supporting it once it is operational, as NSF will not allow user charges to the astronomy community. We learned of a similar circumstance at another university involving a gas-phase sequencer funded by an NIH grant; the proposal had requested funds for a supporting technician, but these were cut by the agency.

Excess Property

The federal excess property program makes research (and other) equipment available to universities under certain conditions. Equipment made available through the excess property program is usually useful to researchers, but is not state of the art. It includes items such as machine tools, vehicles, trailers, motors, pumps, cameras, and machine parts. These items reduce the cost of performing research but add to the administrative burden because of extensive recordkeeping requirements.[21,22]

The excess property program was modified in 1976 by Public Law 94-519, implemented by regulations on October 20, 1977.[23] Congress purposely placed restraints on the program because of abuses by many local governments and other grantees. Public Law 94-519 also liberalized the surplus property programs so that surplus property became available to a wider group of nonprofit organizations. It is important here to distinguish between excess property and surplus property. Excess property is that which is no longer needed by the agency that owns it and therefore is offered by the General Services Administration to all other federal agencies. If no agency needs it, it becomes surplus property. Now that a larger audience has access to surplus property, some universities are finding items heretofore easily obtained at state agencies for surplus property to be first reserved for other nonprofit entities.

The 1977 regulations that implement PL 94-519 appeared to be a deliberate attempt to discourage agencies from giving excess property to grantees. The discouragement took the form of imposing on the agencies intricate and unreasonable requirements for recordkeeping, reporting, and other paperwork. One example is the requirement that "all nonfederal screeners shall be subject to certification by federal authority." That is, a university researcher must state qualifications to screen excess property. Additionally, the researcher must submit a passport-style photograph with signature.

Investigators inquire from time to time about the possibility of reestablishing the excess property program as it was before 1976, when excess property could be obtained with ease.

DOE is upgrading and enhancing its excess property program to provide used instrumentation from DOE-supported national laboratories to universities for use in energy-related research and educational programs. Current DOE funding is not a prerequisite. Lists of excess equipment are available at designated DOE sites and are published monthly by the Government Printing Office.

Generally smaller instruments, such as microscopes, oscilloscopes, spectrometers, and chromatographs are made available on a first-come basis. Universities with DOE research grants may also gain access to the list of eligible equipment through DOE-RECON, an interactive, computer-based system managed by the agency's Office of Scientific and Technical Information at Oak Ridge, Tennessee. For other investigators, the data base is being put on a microcomputer for access by terminal and modem via telephone in a pilot program scheduled for operation in 1985.

Federally Subsidized Loans

Four programs are authorized under the Higher Education Act of 1965 (PL 89-329) to provide loans or interest subsidy grants on loans from nonfederal sources. They would reduce borrowing costs to universities for the construction, reconstruction, or renovation of academic facilities, which could include research equipment. The loan programs are unfunded, however, and the interest subsidy program is funded only to pay interest subsidies on prior loans. No equipment-specific federal loan program is currently authorized.

We analyzed the potential usefulness of a loan subsidy program by developing hypothetical models and comparing costs (see Appendix D). We looked at three alternatives: loan guarantee, loan guarantee with interest subsidy, and direct loan with low interest. The loan guarantee appears to have no particular advantage. Of the two remaining alternatives, the direct, low-interest loan would be cheapest, given favorable rates of interest. We have not assessed the potential effects of the loan programs hypothesized in Appendix D on the overall distribution of public funds for academic research and research equipment. One question that would warrant attention is whether such programs would encourage expansion of the nation's total research capacity, as opposed to upgrading or replacing equipment already in place in research institutions. A broader issue would be the effectiveness of loan programs, in terms of both economic and scientific efficiency, relative to other federal options for funding academic research equipment.

FEDERAL REGULATORY ISSUES

Federal regulations play an important role in the acquisition, management, and use of equipment for federally supported research at universities. Sometimes they create barriers to acquisition, complicate management, and may discourage appropriate use of research equipment. Because regulations that deal with research equipment are designed to control, rather than facilitate, its acquisition, management, and use, they hamper innovative approaches to more effective use of existing resources. More precisely, federal regulations are usually framed in language that permits both universities and the government to accommodate individual circumstances. It is the application or interpretation of the rules that appears in most instances to create barriers.

The most critical barriers are barriers to cost recovery, since these are the ones most likely to influence the acquisition decision. Our approach to identifying barriers began with a regulatory inventory in each area of acquisition, management, and use. It also entailed a careful assessment of whether the actual rule or its various interpretations were creating barriers.

Regulatory Framework

For grants, the principal governmentwide rules controlling the acquisition, management, and use of federally supported research equipment are contained in two Office of Management and Budget (OMB) circulars: OMB Circular A-21 (Principles for Determining Costs Applicable to Grants, Contracts, and Other Agreements with Educational Institutions) and OMB Circular A-110 (Uniform Administrative Requirements, Grants, and Agreements with Institutions of Higher Education).

These circulars are often supplemented by agency issuances, but those issuances are not supposed to be more restrictive than the OMB circulars. OMB Circular A-21 states, "Agencies are not expected to place additional restrictions on individual items of cost." OMB Circular A-110 says, "the standards promulgated by this Circular are applicable to all Federal agencies...exceptions from the requirements of the Circular will be permitted only in unusual cases. Agencies may apply more restrictive requirements to a class of recipients when approved by the Office of Management and Budget." Agency supplements, however, are not always consistent with OMB guidance. Between the foregoing principles and their application in individual circumstances, a wide gap often exists.

For contracts, the Federal Acquisition Regulation (FAR) and OMB Circular A-21 are the principal governmentwide rules controlling the acquisition, management, and use of federally supported research equipment. The basic FAR is further supplemented by agency issuances. The Department of Energy, for example, supplements the FAR by its Department of Energy Acquisition Regulations (DEAR). The Department of Defense does the same with the Defense Federal Acquisition Regulation Supplement (DFARS), and so on. All of this follows principally from the basic grants statute, the Federal Grant and Cooperative Agreement Act (PL 95-224) and three procurement statutes.[24] Only specific parts of each of these circulars and/or grant or procurement rules are concerned with the acquisition, management, and use of research instrumentation.

Table 1 shows the principal contract rules that affect research equipment. Table 2 shows the principal grant rules that affect research equipment. An inventory was necessary because whenever instances of regulatory barriers were raised, it was essential to identify which federal regulations created them.

Several terms warrant explanation. First, the terms equipment, instrumentation, and personal property are synonymous as used here. Second, equipment or property is defined in OMB Circular A-21 [Section J.13.a(1)] as a tangible item having a useful life of more than two years and an acquisition cost of $500 or more. Third, the FAR governs procurement by all federal agencies and applies to all contractors.

Barriers to Acquisition and Optimum Management and Use

The most troublesome barriers to acquisition and optimum management and use of equipment, as mentioned earlier, are those dealing with cost recovery. A notable example is the lack of a regular mechanism that permits the cost of equipment to be recovered directly from research grants by spreading the cost over several grant-years (see previous discussion under Funding Mechanisms). Other barriers we identified include uncertainty of title to equipment, requirements for matching funds, restrictions on combining funds, and the extensive reporting and approval requirements for obtaining equipment. Equipment screening and inventory requirements were cited as expensive and unnecessary paperwork burdens.

The Uncertainty Barrier

The uneven application and inconsistent interpretation of the rules occur at several points in the system owing to the practices

TABLE 1 Regulations Affecting Cost-Reimbursement Contracts That Include Acquisition of Research Equipment

Agency	Acquisition and Title	Management and Use	Records and Reports	Cost Recovery
Principal Regulations				
DOD/GSA/NASA FAR	35.014 45.302-1 (Facilities only) 52.245-5(c)(4) Alternate 1 52.244-2	52.245-5 (e)-(1) (Government Property only)	52.245-5(c)(4) Alternate 1	35.014(b)(4) 52.245-5(c)(4) Alternate 1
OMB Circular A-21 (FAR 31.303)	J.13.b.(2) and J.38 C.4.b.		J.9.e.	J.9 and J.17.e

Agency	Acquisition	Management and Use	Records and Reports	Cost Recovery
Supplemental Agency Regulations				
DHHS: HHSAR				
DOD: DFARS	235.014			
	Page 252.235-14 (2 clauses)	Page 252.235-15		
	270.601 (ADPE)	270.605 (ADPE)		
NSF: NSFAR				
DOE: DEAR	917.7108	917.7113 (SRC) Article B-IX		917.7108-1(d)
	917.7113 (SRC) Article B-IX	945.104-70	945.102-70	
	935.014	945.5	945.505-14	
		952.245-5	952.245-5	
USDA: AGAR				
NASA: NASA FS	1835.014 1845.502-72 1845.70	1845.72	1845.505-670	

NOTE: FAR, Federal Acquisition Regulation; HHSAR, Health and Human Services Acquisition Regulation; DFARS, Defense Federal Acquisition Regulation System; NSFAR, National Science Foundation Acquisition Regulation; DEAR, Department of Energy Acquisition Regulation; AGAR, Agriculture Acquisition Regulation; NASA FS, National Aeronautics and Space Administration Acquisition Regulation.

TABLE 2 Principal Regulations Affecting Grants That Include Acquisition of Research Equipment

Agency	Acquisition and Title	Governmentwide Management and Use	Records and Reports	Cost Recovery
OMB				
Circular A-21	3.13.b.(2), 3.38 and C.4.b.		3.9.e	3.9., 3.18.e
Circular A-110, Attachment N	para. 5	paras. 5 and 6	paras. 5 and 6	
Circular A-110, Attachment O	paras. 3.b. and 3.c.			
Agency Provisions To Implement OMB Circulars				
HHS: PHS Grants Policy Statement	Pages 32 and 35 (Addendum) 45, 48-49, 51, 81	Pages 48-50, 81		Pages 32, 33
DOD: AFOSR[a] Brochure	Page 14	Page 15	Page 15	
NSF: Grant Policy Manual	GPM 512.3, 515 524, 772.1	GPM 204.2, 332, 773		
DOE/OER:[b] Proposed 10 CFR[c] Part 605	sec. 605.17(a)(1)			
USDA: 7 CFR Part 3015	sec. 3015.164, sec. 3015.196	sec. 3015.165-.170		
NASA: Grant and Cooperative Agreement Handbook	para. 408	para. 408, para. 508(d), para. 509	sec. 1509	

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[a] Air Force Office of Scientific Research.
[b] Office of Energy Research.
[c] Office of Code of Federal Regulations.

of agency program officers, contract/grant officers, and auditors. Although federal regulations, as written, almost always give the government and the universities sufficient latitude to accommodate individual circumstances, well-meaning government officials interpret the regulations in ways that vary from region to region and from agency to agency. These inconsistent interpretations cause many university officials to behave cautiously, especially in generating innovative debt instruments to secure costly, short-lived, state-of-the-art research equipment. They already have tough decisions to make on accumulating debt, without having to worry that, sometime in the future, disallowances may be sustained on the basis of circumstances then existing, rather than on circumstances at the time of acquisition. Uncertainty is a critical barrier.

Cost-Recovery Barriers

In addition to the inability to recover the cost of equipment directly over several years, we identified three regulatory barriers to acquisition, and all deal with restrictions on cost recovery. They are (1) the inability to recover interest on borrowed funds, (2) the unrealistically low allowance for equipment use, and (3) the prohibition against setting an optimal price (user charge) for equipment use and replacement.

Recovery of Interest The first barrier leaves recovery of the full cost of a piece of equipment uncertain. OMB Circular A-21 was amended in August 1982 to give federal agencies the discretion to approve interest on equipment financing as an allowable indirect cost. This discretion was restricted to interest on externally borrowed funds. Interest on a university's own funds used to finance equipment is not an allowable cost. There are instances where agencies have approved recovery of interest on external borrowing, but we found several cases in which approval was denied. A decision not to allow recovery of interest costs is often sufficient disincentive to cause academic decision makers not to use debt financing to acquire research instruments from either internal or external sources.

Use Allowance/Depreciation The second barrier is the unrealistically low allowance permitted for federal reimbursement of the use of equipment purchased with nonfederal funds. This allowance is called a "use allowance" and is computed at an annual rate not to exceed 6 2/3 percent of acquisition cost. The full cost is thus recoverable in no less than 15 years, but the realistic life of state-of-the-art research equipment is three to five years. Recognizing the disadvantage of the use allowance method, some universities wish to convert to a depreciation method of cost recovery. OMB Circular A-21 permits such conversion and permits full recovery of the cost of an asset, notwithstanding a university's previous decision to rely on the use allowance method. The Department of Health and Human Services (DHHS) does not object to the conversion, but will only permit recovery of equipment costs as if the equipment were being depreciated during the years it was actually covered by the use allowance. This interpretation has the effect of denying full recovery of the cost of equipment. As noted at the outset, DHHS audits 95 percent of all colleges and universities.

Government rules permit depreciation or use allowance only on equipment not purchased by the federal government. However, 63 percent of all academic research instruments purchased in 1983 was acquired with federal funds. These items cannot be depreciated nor may a use charge be assigned to recover the purchase price from federal awards.

A second problem in switching from use allowance to depreciation is that depreciation will usually result in more rapid cost recovery, which in turn raises indirect cost rates. Increases in indirect cost rates are not acceptable to some investigators for any reason.

User Charges The third cost-recovery barrier to acquisition is the stricture on differential pricing of centralized service facilities and provision for reasonable replacement cost of the equipment involved if it is federally financed. These specialized service centers contain instruments like central computer equipment or electron microscopes. OMB Circular A-21 (Section J.38) says the cost of using these facilities shall be charged directly to users based on actual use and a schedule of rates that does not discriminate between federal and nonfederal activities including use by the university for internal purposes. But the circular also says, "where it is in the best interest of the Government and the institution to establish alternative costing arrangements such arrangements may be worked out with the cognizant Federal agency."

The cost of using large centralized and specialized pieces of equipment often is set too high for optimal use by all investigators. Where individual project grants are not funded well enough to permit paying full costs, differential pricing would encourage greater use of a facility but would necessarily mean charging some users more than others. While the cognizant agency has the authority to establish alternative arrangements, we found no instances of differential pricing. It is unlikely that such arrangements can actually be established, unless the university offers its own money to subsidize the facility. Even if one were able to recover full operating costs, there is no provision for setting a fee for eventually replacing or modernizing the equipment. The government argues that an allowance for replacement is tantamount to paying for an instrument twice and, further, that a set-aside for replacement is without benefit of scientific review. Again, these uncertainties and inconsistencies mitigate against acquisition and effective use of research equipment.

Matching Requirements

Federal agencies that award funds for research equipment may expect or require universities to contribute funds toward the cost of such equipment. Investigators argue that the required contributions, or matching funds, are usually too great and point out that the university's payment of costs such as installation, operation, and maintenance is not as a rule considered part of the match. The governmentwide rules that apply to matching are contained in OMB Circular A-110, Attachment E. The rules in Circular A-110 are not in themselves burdensome, but each federal agency uses different criteria to decide what it considers an acceptable contribution. It is the unspecified match, or the uncertainty of what is acceptable, that creates a perception of inconsistency in federal regulations on matching.

Actually, the amount and character of a university's matching contribution are determined by the individual agency and usually are consistent with its intent and program purpose. Program managers are given broad latitude in setting matching requirements. They argue that this latitude is needed to assure the best possible use of federal money.

Matching, as the term is used here, differs from cost sharing, which is the requirement that the university contribute to the total cost of a research project, which may or may not involve equipment.

Ownership of Equipment

Some federal agencies do not vest title to equipment in the university receiving the support. In this instance, the problem is found in both the letter and the interpretation of the regulations. Without assurance of title, investigators hesitate to combine university funds with federal funds to acquire an instrument--they may find that it belongs entirely to the federal government.

To cite an example, the Public Health Service (PHS) vests title to equipment purchased under its grants without obligation on the part of the university.* This practice is consistent with the intent of the Federal Grant and Cooperative Agreement Act, which states,

> The authority to make contracts, grants, and cooperative agreements for the conduct of basic or applied scientific research at nonprofit institutions of higher education, or at nonprofit organizations whose primary purpose is the conduct of scientific research shall include discretionary authority, when it is deemed by the head of the executive agency to be in furtherance of the objectives of the agency, to vest in such institutions or organizations, without further obligation to the Government, or on such other terms and conditions as deemed appropriate, title to equipment or other tangible personal property purchased with such funds.[25]

The Department of Energy, on the other hand, does not automatically vest title to equipment purchased under its contracts.† Such inconsistent practices among agencies inhibit efficient acquisition, management, and use of equipment.

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*Consistent with OMB Circular A-110, the PHS reserves the right to require transfer of title to equipment from one grantee to another or to the federal government even though title was vested in the university upon acquisition. This is known as "conditional" title, but has created no reported problems. This option must be exercised within 120 days after the end of PHS support for the project. Other agencies that transfer title upon acquisition also vest conditional title (Code of Federal Regulations 45, sec.74.136).

†The Department of Energy does not now award many research grants but relies rather on research contracts. Departmental policy urges that equipment title be transferred to universities upon acquisition, but investigators say that DOE ignores its own policy. Recently the department announced that the Office of Energy Research would be issuing a significant number of special research grants. An announcement in the Federal Register to facilitate those grants appeared on April 15, 1985 (50 FR 14856); we understand that DOE operations offices will be encouraged to vest title upon acquisition and may vest title to equipment previously purchased on contracts.

Problems arise when investigators attempt to acquire an instrument by combining funds from their own grants or contracts from the same or different agencies, for example, or when two investigators want to purchase an instrument jointly with funds from the same or different agencies. Where title to the instrument vests in the government, rather than the university, it is easy to understand the reluctance of a university official to arrange financing. The government may prove to be unable or unwilling to continue support for the project at an appropriate level, leaving the university to pay for a piece of equipment that belongs to the government.

Inconsistencies in Federal Contract Rules

The Federal Acquisition Regulation was described earlier as the basic governmentwide set of rules governing all federal procurement including the acquisition, management, and use of federally supported research equipment under contracts. The FAR is of recent origin (April 1984) and was developed to resolve the inconsistencies of the old agency-by-agency procurement regulations. The intent was admirable, but the agencies were permitted to develop supplements that implement the FAR, and these in some instances created new inconsistencies. In several cases, there are inconsistencies among the agency supplements. In other instances, the FAR itself is internally inconsistent.

For universities the FAR presents two problems.[26] First, definitions of equipment and facilities do not distinguish between industrial facilities, plant equipment, and special tooling, on the one hand, and research facilities and equipment on the other. Because the definitions of equipment are not clear, universities have long been subjected to unrealistic requirements, such as screening requests for state-of-the-art equipment through the Defense Industrial Plant Equipment Center (DIPEC) before the equipment can be purchased with DOD funds.* Such screening is required because research equipment is included in the definition of the term "industrial plant facilities."

The universities we visited felt that the descriptions of equipment in the DIPEC inventory do not suffice to permit a federal property officer to determine whether an instrument in the inventory is an adequate substitute for the one requested. We encountered no one who could identify scientific or technical equipment acquired via DIPEC screening. Hence the required time-consuming screening is wasteful for both the universities and the government and serves no useful purpose for research equipment.

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*The National Aeronautics and Space Administration has a similar screening system, the Equipment Visibility System (EVS).

The DOD definitions of what constitutes equipment are so oriented toward manufacturing and production as to mean little to research contracts with universities.

The second difficulty is the inconsistency of the FAR contract clauses governing vesting of title, which are not in accordance with PL 95-224. This law contains the statutory authority for vesting title to equipment. The policies on title to equipment acquired by universities provide that the "contractor shall automatically acquire and retain title to any item of equipment costing less than $5,000" and "if purchased equipment costs $5,000 or more," the parties may agree that title vests in the contractor on acquisition, or they may select among several other options. The contract clause that implements this policy provides that title ordinarily vests in the government, rather than with the contractor. It also provides, however, that title to equipment costing less than $1,000 may vest in the contractor on acquisition but only if, before each acquisition, the contractor has obtained agency approval.

Capital Equipment Thresholds and Inventory Requirements

OMB Circulars A-21 and A-110 specify cost thresholds for capitalizing equipment that are inconsistent and unrealistically low. The threshold is $500 in Circular A-21 and $300 in Circular A-110.

OMB Circular A-21 defines equipment as "tangible personal property having a useful life of more than two years, and an acquisition cost of $500 or more per unit." OMB Circular A-110 defines equipment as "tangible personal property having a useful life of more than one year, and an acquisition cost of $300 or more per unit."

OMB Circular A-21 addresses capitalization levels for purposes of cost recovery and allowability; OMB Circular A-110 addresses the management of equipment. Circular A-21 also requires approval in advance of purchase of special-purpose equipment costing $1,000 or more.

If colleges and universities wish to be reimbursed for depreciation or use allowance on equipment, they must maintain property records and conduct a physical inventory at least once every two years. The university must ensure that the equipment is used and needed. Colleges and universities that seek such reimbursement keep property records and conduct inventories, but those inventories are for purposes of cost reimbursement, rather than for equipment management.

The difference in the two circulars' capitalization thresholds—$500 versus $300—creates difficulty in equipment management. The Circular A-110 definition requires keeping track of significantly more items than does the Circular A-21 definition. Management of the inventory would go more smoothly if both thresholds were raised and made uniform.

Two universities we visited estimate that a threshold of $1,000 would halve the number of items in the typical university inventory of capital equipment while retaining 80 percent of the combined value of the equipment. At a third university, 80 percent of the items in the inventory of equipment bought in 1983 accounted for less than 20 percent of the dollar value of the inventory.

Circular A-110 requires that universities "assure the avoidance of purchasing unnecessary or duplicative items." This requirement is interpreted to mean that universities must screen their equipment inventories prior to purchase. Faculty investigators generally are willing to share to cut costs, but we were told that the $300 threshold requires considerable screening for items that are not economically suited to sharing. Some universities have negotiated higher screening thresholds with their auditors. The screening level at one university we visited, for example, is $10,000. It accounts for 3.2 percent of the items in the inventory of equipment bought in 1983 and for 50 percent of the dollar value.

Prior Approval Systems

Purchases of equipment costing more than $1,000 and not otherwise approved for acquisition with NIH and NSF project-grant funds ordinarily can be approved by the university under the NIH Institutional Prior Approval System (IPAS) and the NSF Organizational Prior Approval System (OPAS). These systems eliminate some of the postaward restrictions attached to the project grant, such as the requirement for prior approval by the agency to incur certain costs or to shift funds among budget categories. IPAS and OPAS emphasize the grantee's flexibility to allocate resources to achieve optimum research outputs and are valued highly by investigators and administrators. They reduce turnaround time on requests from six or more weeks to a few days, thereby permitting the university to take advantage of timely price discounts or other special arrangements.

Under IPAS and OPAS, the universities are charged with adhering to both the agencies' grant regulations as well as university standards. Both individual transactions and the procedures themselves are subject to review by the agency and the auditor. The universities must retain documentation of their IPAS/OPAS transactions.

The NSF OPAS contains a provision that permits the university to incur cost up to 90 days before a grant is awarded. This provision can reduce lags in start-up caused by delays in delivery of equipment. It also gives the university ample opportunity to obtain maximum benefit from negotiations, including taking advantage of tax incentives to industry for donations and bargain sales of equipment. The OPAS makes it easier to combine funds from NSF grants when the grants are scientifically related. Additionally, the university is authorized to rebudget grant funds for renovations costing less than $10,000.

The Public Health Service is currently in the second phase of an experiment with the IPAS. This experiment extends additional approval authority to the university. It includes the ability to make decisions on the purchase of general-purpose equipment to be used for scientific applications. General-purpose equipment includes items like cargo vehicles, computing equipment, cameras, and refrigerators.

The Office of Naval Research (ONR) operates a system that, among other functions, moves the locus of government decision making closer to the campus. ONR resident representatives on or near campuses around the country can approve purchases locally, which considerably expedites the acquisition process. The resident representative is usually authorized to approve purchases on behalf of agencies other than DOD. This system provides certain benefits comparable to those of IPAS and OPAS, although it does not constitute delegation of prior approval authority to the universities.

RECOMMENDATIONS

Traditional federal funding mechanisms, although they account for well over half of expenditures on academic research equipment, do not on balance comprise adequate means of regularly replacing obsolete or worn-out equipment. Current special equipment programs, operated outside the traditional funding channels, are extremely useful. Still, they were designed largely to respond to an emergency and, at present levels, obviously are not a long-term solution to the equipment problem.

Federal regulatory practices are an element of the problem. Few federal regulations directly prevent the acquisition of research equipment by universities or hamper its operation, maintenance, and replacement; however, the interpretation of regulations does impede acquisition and especially complicates management and replacement and modernization of research equipment.

We recommend...

1. **That the heads of federal agencies supporting university research issue policy statements aimed at removing barriers to the efficient acquisition, management, and use of academic research equipment.** Few federal regulations, as written, contribute directly to the equipment problem. Inconsistent interpretation of regulations by federal officials, however, complicates the purchase, management, and replacement of research equipment and leads to unnecessarily conservative management practices at universities. Desirable actions are summarized in the recommendations below.

2. **That federal agencies more adequately recognize and provide for the full costs of equipment, including operation and maintenance, space renovation, service contracts, and technical support by...**

...providing these costs in project grants and contracts or ensuring that recipients have adequately provided them.

...accepting universities' payment of costs such as installation, operation, and maintenance as matching funds on programs that require matching contributions by universities.

3. **That federal agencies adopt procedures that facilitate spreading the cost of more expensive equipment charged directly to research-project awards over several award-years and allow the cost and use of equipment to be shared across award and agency lines.** Individual research-project grants and contracts normally can accommodate equipment of only modest cost. Investigators, moreover, have difficulty combining funds from awards from the same or different agencies to buy equipment.

4. **That federal auditors permit universities to recover the full cost of nonfederally funded equipment from federal awards when they convert from use allowance to depreciation.** Office of Management and Budget (OMB) Circular A-21 permits such conversion as well as recovery of full cost. Auditors of the Department of Health and Human Services, however, permit recovery only as if the equipment were being depreciated during the time it was in fact covered by the use allowance. This practice, in effect, denies recovery of full cost.

5. **That the Office of Management and Budget make interest on equipment funds borrowed externally by universities unequivocally an allowable cost by removing from OMB Circular A-21 the requirement that agencies must approve such charges.** Interest on externally borrowed funds has been a permissible cost since 1982 at the discretion of the funding agency, but agencies have shown significant reluctance to permit it. The perception of inability

to recover interest costs may lead university officials to decide against seeking debt financing for equipment.

6. **That all federal agencies vest title to research equipment in universities uniformly upon acquisition, whether under grants or contracts.** Federal regulations on title to equipment vary among agencies, and such variability inhibits efficient acquisition, management, and use of equipment. Without assurance of title, for example, investigators hesitate to combine university funds with federal funds to acquire an instrument not affordable by a single sponsor.

7. **That the Office of Management and Budget make federal regulations and practices governing management of equipment less cumbersome by...**

...setting at $10,000 the minimum level at which universities must screen their inventories before buying new equipment and, above that minimum, permitting universities and agencies to negotiate different screening levels for different circumstances.

...raising the capitalization level for research equipment to $1000 in OMB Circulars A-21 (now at $500) and A-110 (now at $300) and giving universities the option of capitalizing at different levels.

8. **That the Department of Defense eliminate its requirement that the inventory of the Defense Industrial Plant Equipment Center (DIPEC) be screened for the availability of specialized scientific equipment requested by universities before new equipment is purchased.** The descriptions of equipment in the DIPEC inventory do not permit a federal property officer to determine whether a scientific instrument in the inventory is an adequate substitute for the one requested. Hence, the requirement for screening is wasteful for both universities and the government.

9. **That other federal agencies adopt the NIH and NSF prior approval systems.** Purchases of equipment with federal funds ordinarily must be approved in advance by the sponsoring agency. Purchases can be approved by the university, however, under the NIH Institutional Prior Approval System and the NSF Organizational Prior Approval System. These systems markedly improve speed and flexibility in acquiring equipment.

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2

The State Role in the Acquisition and Management of Research Equipment

INTRODUCTION

State governments play significant but often conflicting roles in regard to academic research equipment. On the one hand, they provide important funding for such equipment both directly and, by means of tax benefits, indirectly. On the other hand, states often constrain the acquisition and management of research equipment through regulatory controls and restrictions on public universities' general financial flexibility.

Data on state funding of research equipment in universities are sparse, and trend data do not exist. The National Science Foundation's (NSF's) National Survey of Academic Research Instruments has developed figures on the amount, condition, and cost of existing research equipment. The figures show that states directly funded 5 percent of the aggregate acquisition cost of major research instrumentation systems in use in academe in 1982-1983 (Table 3). This percentage is probably an underrepresentation of state support for many public institutions, since the self-reported university contribution may include general-purpose state appropriations. State funds for research equipment are rarely available to private universities; the NSF data show that private schools received only 2 percent of direct state funding for equipment covered by the survey, whereas public schools received 98 percent (Table 4).

States provide some funding for research and development at colleges and universities, and an unknown fraction of these expenditures goes for research equipment. State and local governments accounted for 15 percent of total spending on academic R&D in 1953 and 7 percent in 1983 (Figure 2, Chapter 1). The decline reflects the rise in federal funding during that period (Appendix A). In constant dollars, state funding grew about 8.9 percent annually during 1953-1967 and about 1.8 percent annually during 1967-1983. Federal funding of academic R&D, in real terms,

TABLE 3 Sources of Funds for Acquisition of Academic Research

		Federal			
	Total	Total	NSF	NIH	DOD
Total, Selected Fields	$1,178.0	$640.3	$230.8	$176.5	$103.9
	100%	54%	20%	15%	9%
Agricultural Sciences	36.1	7.8	1.7	1.3	0
	100%	21%	5%	4%	-
Biological sciences, total	381.3	198.5	35.3	149.7	2.1
	100%	52%	9%	39%	1%
Graduate schools	156.1	80.6	24.5	48.9	1.0
	100%	52%	16%	31%	1%
Medical schools	225.2	117.9	10.8	100.8	1.2
	100%	52%	5%	45%	-
Environmental sciences	92.3	45.7	16.5	0.5	6.6
	100%	50%	18%	-	7%
Physical sciences	351.9	229.1	116.1	19.5	32.3
	100%	65%	33%	6%	9%
Engineering	218.9	106.4	35.1	2.7	45.8
	100%	49%	16%	1%	21%
Computer science	46.9	21.5	10.8	0.3	9.1
	100%	46%	23%	1%	19%
Materials science	34.1	24.3	13.5	0.7	5.4
	100%	71%	40%	2%	16%
Interdisciplinary, not	16.6	7.0	1.8	1.9	2.4
elsewhere classified	100%	42%	11%	11%	15%

[a]Individuals and nonprofit organizations.

NOTE: Sum of percents may not equal 100 percent because of rounding.

SOURCE: National Science Foundation, National Survey of Academic

Equipment in Use in 1982-1983, by Field (Dollars in Millions)

Funding				Nonfederal Funding			
DOE	NASA	USDA	Other	Univ. Funds	State Govt.	Business	Other[a]
$63.1	$30.8	$5.0	$30.2	$371.5	$61.5	$43.2	$61.5
5%	3%	-	3%	32%	5%	4%	5%
0.3	0.3	2.7	1.5	17.8	6.7	1.8	2.1
1%	1%	7%	4%	49%	18%	5%	6%
3.5	0.4	1.9	5.5	131.2	18.6	6.5	26.5
1%	-	-	1%	34%	5%	2%	7%
0.7	0.4	1.7	3.5	48.2	13.0	4.3	10.0
-	-	1%	2%	31%	8%	3%	6%
2.9	0	0.2	2.1	83.0	5.5	2.3	16.4
1%	-	-	1%	37%	2%	1%	7%
8.2	5.4	0	8.5	27.5	7.2	8.4	3.5
9%	6%	-	9%	30%	8%	9%	4%
33.0	22.3	0.1	5.7	92.2	6.6	4.1	20.0
9%	6%	-	2%	26%	2%	1%	6%
14.4	2.2	0.3	5.8	78.5	13.5	13.1	7.4
7%	1%	-	3%	36%	6%	6%	3%
0.3	0	0	1.0	11.5	4.9	7.7	1.2
1%	-	-	2%	25%	10%	16%	3%
3.4	0	0	1.3	6.0	2.6	0.6	0.6
10%	-	-	4%	18%	8%	2%	2%
0	0	0	0.9	6.8	1.5	0.9	0.4
-	-	-	5%	41%	9%	6%	2%

Research Instruments and Instrumentation Needs.

TABLE 4 Acquisition of Research Instrument Systems in Use in Purchase Cost (Dollars in Millions)

		Federal			
	Total	Total	NSF	NIH	DOD
Total	$1,178	$640.3	$230.8	$176.5	$103.9
	100%	100%	100%	100%	100%
Type of University					
Private	429.9	268.3	102.8	74.7	53.1
	36%	42%	45%	42%	51%
Public	748.1	372.0	128.0	101.8	50.8
	64%	58%	55%	58%	49%
System Purchase Cost					
$10,000-$24,999	324.9	176.7	43.5	82.6	21.5
	28%	28%	19%	47%	21%
$25,000-$74,999	372.6	194.2	68.9	53.2	37.4
	32%	30%	30%	30%	36%
$75,000-$1,000,000	480.5	269.4	118.4	40.7	45.0
	41%	42%	51%	23%	43%

[a] Individuals and nonprofit organizations.

NOTE: Sum of percents may not equal 100 percent because of rounding.

SOURCE: National Science Foundation, National Survey of Academic

1982-1983 by Source of Funds, Type of University, and System

Funding				Nonfederal Funding			
DOE	NASA	USDA	Other	Univ. Funds	State Govt.	Business	Other[a]
$63.1	$30.8	$5.0	$30.2	$371.5	$61.5	$43.2	$61.5
100%	100%	100%	100%	100%	100%	100%	100%
15.2	12.8	0.3	9.4	109.9	1.3	24.7	25.7
24%	42%	6%	31%	30%	2%	57%	42%
47.9	17.9	4.8	20.8	261.7	60.1	18.5	35.9
76%	58%	94%	69%	70%	98%	43%	58%
14.2	4.9	2.8	7.3	102.7	20.1	8.6	16.8
22%	16%	56%	24%	28%	33%	20%	27%
15.1	8.6	1.8	9.3	126.2	20.3	13.9	18.0
24%	28%	36%	31%	34%	33%	32%	29%
33.8	17.3	0.4	13.6	142.6	21.0	20.7	26.7
54%	56%	8%	45%	38%	34%	48%	43%

Research Instruments and Instrumentation Needs.

grew about 1.6 percent annually during 1967-1983 but from a base more than eight times the base for state and local government.

The critical question is the degree to which state funds and tax benefits intended specifically to aid academic research are countered by constraints general to state government. State procurement laws, for example, tend to be highly conservative, and creative financing is viewed warily. States traditionally rely on negative controls to assure fiscal integrity. Such controls do not lend themselves readily to expeditious acquisition and upgrading of complex and costly research instrumentation or to alternative modes of financing. States typically do not have a regular mechanism for replacing obsolete research equipment nor do they recognize its rapid obsolescence when providing initial funding for equipment purchases. Other constraints include bars to the use of equipment by private entities and replacement policies inconsistent with the unique nature and often quite short useful life of research equipment. Finally, most states continue to treat the acquisition of research equipment, almost without regard for its cost, as an operating expense. Thus, the capital financing methods common in business, and used increasingly by private universities, remain the exception for state-funded equipment.

MODES OF STATE SUPPORT

The state and federal approaches to funding research equipment differ in part on philosophical grounds. For example, states sometimes do not consider research and graduate study among their primary responsibilities; more specifically, they consider basic research a federal responsibility. Some states, in fact, budget only for instruction in their institutions of higher education.

State support is usually institutional, with only limited consideration of specific pieces of equipment; federal support, in contrast, is mainly project oriented and independent of the overall financing of the institution. State funding is very likely to be in a form that merges support for equipment into a general operating base; a federal research grant is likely to anticipate the acquisition of specific equipment. State funding of scientific equipment usually is associated with new buildings or major new programs. Most state purchasing regulations draw no distinction between research equipment and other equipment, whether for use by universities or other state agencies. State allocations that cover equipment, moreover, usually also cover diverse and undifferentiated instructional, administrative, and maintenance needs.

Federal and state policies toward public and private universities also differ significantly. With only minor exceptions, the federal government treats public and private universities alike in the award and management of funds for research and research equipment. States, on the other hand, impose on public universities considerably more control, particularly fiscal control, than they impose on private universities. Except for controls entailed by their use of state borrowing authority, private universities are exempt from virtually all state controls on the acquisition and management of research equipment.

State support of colleges and universities is largely shaped by the state appropriations process. Typically the process supplies operating and capital funds for a budget period of one or two years. The "base budget" reflects the costs of operating and maintaining the institution at existing levels; generally it includes allocations, often quite small, for buying and maintaining equipment. The base budget may or may not reflect inflation, depending on state practice. At the end of the budget period, unexpended or uncommitted balances generally revert to the state's general fund.

Proposals for new or expanded programs, and the associated equipment, must include well-justified cost analyses and projections and must be submitted for legislative scrutiny during the appropriations process. The economic health of the state and the interests of its political leadership are critical factors in the treatment of such budgetary proposals.

States are usually under heavy pressure to pay for current operations, and very few are able to fund equipment replacement reserves. State budget officers increasingly are requiring public universities to include replacement reserves in their budget presentations. Unfunded reserves, however, set up false expectations, often exacerbated by useful-life tables that are too long relative to the actual useful life of research equipment.

The regulations associated with state support (Appendix E) generally apply to all state agencies and often promote good management and provide checks and balances to ensure that funds are spent appropriately. Still, restrictions on year-end carry over of funds, overly restrictive state purchasing procedures, low dollar values for capitalization of equipment, and state budgeting processes all combine to impose burdens on state universities not common to private universities. Except in unusual circumstances, moreover, state regulations do not recognize the unique character of scientific equipment or the difficulties of acquiring it. In addition to high costs and short technological lifetimes, instruments with the same general specifications, for example, may have different capabilities. Further, the differences may be discernible only to experts in the field.

Fresh Approaches

Many states are seeking ways to foster technological development, and some legislatures have recognized that colleges and universities need capital equipment to compete for federal funding of research and create an environment conducive to economic development. In some states, for example, participants in the budgeting process have had the foresight to provide not just the salaries for new faculty, but also seed money and start-up funds for their research. We visited several such state universities.

The University of New Mexico received $2 million per year for five years (1980-1985) from the state for research equipment and teaching apparatus; the money was part of $5 million per year from a statewide appropriation, which was distributed to public colleges and universities by formula.

The state of Georgia set aside 1 percent of the state's higher education appropriation of $600 million for specific quality improvement programs at state schools. The $6 million allocated in 1984 was used to improve laboratory equipment. It was apportioned according to need; Georgia Tech, for example, got $1 million. Officials anticipate that similar funds will be provided each year, but the focus may change from year to year according to current needs. These funds are used for one-time expenditures without continuing budgetary commitments.

The New York State Foundation for Science and Technology has established centers for advanced technology at seven public and private universities within the state. Support for each of the seven centers is $1 million per year for four years. In addition, the state is supporting a research and development program in engineering at Rensselaer Polytechnic Institute and a major research facility for biotechnology at Cornell University.

The state of Virginia in 1984 appropriated more than $30 million for a Center for Innovative Technology to be operated by a consortium of four universities. It is designed to support research in four areas: genetic engineering, computer-aided engineering, microelectronics, and image processing. The state money is seed money; substantial industrial support is anticipated. The center will provide support for individual projects as well as a central facility.

The North Carolina Board of Science and Technology, a 15-member board established by the governor, did a thorough study of academic research equipment needs in the state. In December 1983 the board recommended that the state appropriate $73 million over five years to universities in the North Carolina system for one-time purchase of equipment and $10.9 million per year for maintenance of equipment.[1] It recommended also that the state allocate $20 million over five years to public and private colleges and universities for matching grants for equipment. As of mid-1985, the North Carolina legislature had not acted on these recommendations.

The North Carolina Board of Science and Technology is designed in part to bring together the scientific and technological resources of government, academe, and industry in the state. One result of the board's activities is the Microelectronics Center of North Carolina (MCNC).[2] It is intended to help the state develop high technology industry by enhancing the research and educational abilities of five universities and a contract research institute. The participants are Duke, Agricultural and Technical College of North Carolina, North Carolina State, the University of North Carolina at Chapel Hill, the University of North Carolina at Charlotte, and the Research Triangle Institute. MCNC thus far has been funded largely by the state and began occupying its own facilities at Research Triangle Park in 1983. Center leaders see great potential for supporting excellent research facilities in integrated circuit technology.

Another technology-fostering device is the provision at some schools of "incubation" facilities for small companies just starting out. The immediate payoff for the university is not likely to be large, but advantages could accrue in the longer term. The state of Georgia in 1980 established such a facility, the Advanced Technology Development Center (ATDC) on the campus of Georgia Tech. The center is designed to catalyze the growth of high technology in the state, and university officials say it is "a spectacular success." The center's location on campus gives companies ready access to Georgia Tech's scientific and engineering resources, both human and physical, and low-cost space for developing, testing, and manufacturing new products is also available on campus. ATDC also serves as a conduit to Georgia's other major research universities--the University of Georgia and Emory University.

Finally, a few states are permitting their public institutions to create structures that encourage public-private cooperation. In 1984, Connecticut authorized the University of Connecticut to establish a Health Sciences Research and Development Corporation which would in turn own a controlling interest in a series of research and development limited partnerships. Although implementation is just under way, this model promises to provide a vehicle that encourages private sector participation in R&D activities without the burdens imposed by direct state control.

Tax Benefits

States also support research and research equipment indirectly through tax benefits. In 34 states whose tax codes follow the federal Internal Revenue Code, tax benefits are available as specified in the Economic Recovery Tax Act of 1981 (see Chapter 5 for detailed discussion). These benefits cover contributions of research equipment to colleges and universities as well as spending on research. In four other states, the tax codes include comparable provisions but with certain variations. In addition, seven states have adopted tax credits designed to foster research and contributions to educational institutions.

CONTROLS ON DEBT FINANCING

Rising costs have led to steady growth in the universities' use of debt financing and leasing to acquire research equipment (see Chapter 4 for detailed discussion). State controls, however, have generally limited public universities' use of these financial vehicles.

Few state universities may directly incur debt except where the debt-financed facility or equipment will generate its own definable revenue stream. Even in such cases, debt financing is usually limited to capital construction. General obligation bonds and other forms of state debt commonly issued to finance buildings, highways, and other permanent improvements remain unavailable for most equipment needs (Appendix F), although research instruments may cost nearly as much and sometimes even more than permanent structures. The distinction is based on presumed useful life: financing equipment with a useful life of perhaps 5 years by means of state debt that will be carried for 30 years has traditionally been considered imprudent.

An exception here is that most states permit the financing of new (or substantially renovated) buildings to include the cost of equipping them. Equipment has generally been taken to include the instrumentation (fixed or movable) required in laboratories or other research facilities in the new or renovated building. This approach helps the university by permitting substantial equipment costs to be financed on a capital basis. On the other hand, it creates the impression that the initial instrumentation and the surrounding building will have similar long-term useful lives. State legislators and budget directors usually will accept the need to replace the instruments before the building, but not the need to replace them in only a few years. Thus, the inclusion of initial equipment with buildings in long-term capital financing can create reluctance to replace the equipment in a timely fashion.

New construction alone cannot meet the need for research equipment in academe. At most state universities, however, equipment that is not included in new construction cannot be financed through the capital route, but must be paid for out of regular appropriations. This requirement, in effect, pits needs for equipment against needs for faculty and other claims on operating funds.

Exceptions to Current Funds Only

The current-funds-only rule is not universal. To buy equipment that is expected to generate revenue, for example, nearly all states allow issuance of revenue bonds that do not constitute state debt. Interest and principal are paid from the earnings produced by the equipment. This vehicle harbors risk, however. If the revenue stream proves inadequate, the institution or the state or both may be forced to service the debt out of general funds, risk default, lose the equipment, or suffer other harm.

Another way to capitalize equipment, including research instrumentation, is pooled debt financing, where the state does not incur a general obligation. Although public as well as private institutions technically have access to pooled equipment funds, private universities have used this alternative the most. The explanation seems to lie in the schools' budgeting processes and the vagaries of state law. Private universities, at least in theory, have relatively unrestricted use of their funds and can shift them as needed to take part in pooled equipment financing. State universities, on the other hand, often are constrained by line-item or object-category budgets that lack the necessary flexibility. Some state universities have solved this problem by classifying outlays for pooled equipment funds as leases and within their power to arrange. As will be seen, however, restrictions on multiyear contracts can limit the utility of this approach.

Another exception to the current-funds-only practice is telecommunications and data processing systems. A number of states have set up debt financing programs to allow their agencies, including public universities, to acquire equipment of both kinds (see also Controls on Purchasing section below). This has been a particularly attractive area for joint ventures, as in the case of a technologically advanced teleport under development by Ohio State University with a consortium of private interests. The teleport is a telecommunications center that has a combination of several satellite-earth terminals, a switching center, and a data processing center and is used as a regional focal point for the reception and transmission of data for a number of users. In this case, the state has stepped aside to allow for the creation of a high-cost facility that would ordinarily be outside of the existing public resource base.

Private as well as public universities have benefited from state-authorized debt financing. Most states now permit private institutions to participate in tax-exempt bond issues that impose no general financial obligation on the state. Many state legislatures have established financing authorities for higher education facilities that are empowered to issue bonds to finance capital projects at private universities. In a growing number of states the proceeds may be used to buy equipment not part of a construction project. California is the primary example of a state that has aggressively promoted pooled issues, the proceeds of which could be used for equipment as well as facilities.

Financing research equipment through debt that is not a general obligation of the state is an important development as more and more states find themselves at or near the statutory or constitutional limit on the money they may owe.

Leasing

Leasing equipment to spread its cost has become common among research universities. Public universities in many states, however, face statutory limits on the duration of contracts, including leases. Such limits, often based on the appropriations period (usually one or two years), restrict the schools' ability to arrange advantageous leases. Even where a long-term lease can be negotiated, it must by law be cancelable annually or biennially, which increases the risk to the lessor and, therefore, the cost to the lessee. Current exceptions that allow multiyear leases are commonly limited to real property or special categories of fixed equipment, particularly telecommunications.

CONTROLS ON PURCHASING

State controls on purchasing and procurement significantly constrain the acquisition of research equipment. Nearly every state requires its public universities to conform to at least some of the standards and procedures for buying equipment that apply to all state agencies. Such requirements include publication of specifications, approved bidder lists, competitive procurement, and the award of contracts to the lowest responsive bidder. Controls on purchasing and procurement usually apply with equal force whether the equipment is bought with current funds or through capital financing.

State controls are frequently more restrictive than federal regulations. They may, for example, require orders to be processed and approved through a statewide purchasing agency, a procedure that often delays acquisition and isolates investigators from discretionary judgments that are essential to the purchasing process.

State purchasing requirements tend to be designed to deal with the acquisition of routine and general-purpose goods: automobile tires, cleaning supplies, and the like. Although often not drafted with the requirements of sophisticated scientific research instrumentation in mind, they often subsume those acquisitions as well. This problem becomes particularly severe because procurements are defined in generic terms; in the case of many items required in the functioning of state government, such a process is both reasonable and indeed an efficient way to control expenditures. With state-of-the-art scientific apparatus, however, the brand-to-brand difference may be far from insignificant. Purchasing officers are primarily interested in saving money, whereas the scientist's main goal is to perform research. The scientist looks for characteristics that might indicate that one product is superior to another; difficulty can arise when university or state purchasing officers are not persuaded of, or do not understand, these subtle differences in instruments or other equipment. Additionally, purchasing officers sometimes do not understand the time constraints on scientific experiments. When purchasing officials fail to see that buying scientific instruments or their components is different from buying tires and batteries, misunderstandings and a degree of conflict are inevitable. Such problems are not confined to state colleges and universities, but they are less common in private institutions.

Competitive bidding on scientific equipment may result in substantial discounts or the inclusion of additional features, spare parts, or expendable supplies, which is good for both the university and the sponsor of the research. But while the Office of Management and Budget Circular A-110 and the Federal Acquisition Regulation require competitive procurement where practicable, state law almost without exception mandates competitive procurement by public universities. In some states, the procurement procedures apply with full force to purchases by state universities even with nonstate funds.

Some states permit exceptions to normal procurement standards. Competitive procurement may not be required, for example, below a specified dollar value and where the item is available from only one source or is needed in an emergency. Often, however, the threshold is so low ($100 in some states) that little scientific equipment falls below it. One public university must ask for bids on all equipment costing more than $700, even when only one vendor can meet the specifications. While a sole-source exemption is useful in principle, its value often is limited severely by narrow definitions of the kinds of acquisitions and the circumstances of their procurement that trigger such treatment. The investigator's view that one of several possible suppliers offers the best or most suitable device, for example, is rarely enough to invoke the exemption. The adequacy of the alternatives is usually determined by state purchasing authorities far from the scene and with little or no scientific background.

Exceptions based on emergency need are likewise of limited utility. State rules tend to define emergencies in terms of protecting health and safety and public property. Thus, a contract to replace a storm-damaged roof may be let promptly and noncompetitively, but a request to acquire equipment noncompetitively to meet a research deadline is likely to be rebuffed. Strict application of state puchasing controls in this manner is particularly troublesome: opportunities for sponsored research often come on relatively short notice, and the ability to pursue the work on a timely basis may be critical to obtaining the grant or contract.

State equivalents of "domestic content" laws also can present problems. These laws give in-state vendors preference in the award of contracts for equipment and services. Although a growing number of states exclude scientific equipment from home-state preference rules, the exceptions generally remain narrow or depend on approval by state purchasing officials.

Public universities have sought to ease the negative effects of state purchasing controls in several ways. One is the use of a university-controlled foundation as a conduit for acquiring research equipment with nonstate funds. In a number of states, however, the ability of such entities to operate outside the framework of state control has been challenged. Some states have subjected university foundations to the same purchasing and procurement rules that apply to the universities, particularly where the foundation is viewed as quasi-public. University foundations not created by statute are less likely to be subject to state control, but some jurisdictions have sought to require even these foundations to adhere to state procurement policies. There are indications that this policy is changing, as more and more states recognize the competitive advantages of allowing their public institutions to create nonpublic subsidiaries to conduct and reap the benefits of scientific research.

State procurement requirements may even extend to private universities that rely on funds from state-sponsored bond issues or debt, direct grants, or contracts. In such cases, the acquisition of equipment and services generally must conform to the state purchasing act, although some states follow the federal example of requiring general adherence to the principles of the procurement rules, but not necessarily to every detail.

States frequently apply particularly strict purchasing controls to data processing and telecommunications systems. These special controls were imposed after many state agencies invested considerable sums in systems that turned out to be incompatible or redundant. The imposition of uniform standards and selection criteria has been reasonably successful but is not always suited to computer and telecommunications systems for use in academic research. In consequence, a number of states have exempted such equipment from special restrictions, and many allow waivers of uniformity standards.

CONTROLS ON USE OF EQUIPMENT

Public universities are commonly governed by "public purposes" language in the state constitution or statutes that limit their freedom to enter agreements with for-profit entities. In terms of the acquisition and use of research equipment, such restrictions place the public university at a disadvantage relative to private universities.

This issue raises several complex questions. First, the very concept of public purpose versus private use is not uniformly defined. In some states the determining factor is the nature of the use; in others it is the identity of the user. Sponsored research is generally viewed as a public purpose. Where the sponsor makes separate use of the equipment, however, or obtains unique rights to results obtained with it, it has been asked whether a private purpose has not overtaken the public one. Questions about private use raise anticompetitive issues as well, owing to the theory that use of state-funded property and equipment for private purposes gives the user an unfair advantage over private competitors.

As a result of these constitutional and statutory limitations, some public universities have turned to the creation of structural appendages that are technically nonpublic and may even be profit making. Several states are actively encouraging this approach in recognition of the need to free their institutions from the constraints imposed on other public agencies, so that they can compete more effectively in the high-technology marketplace. The creation of the separate University of Connecticut Health Sciences Research and Development Corporation was applauded by the state as a means of strengthening the competitive position of the university. Like the university foundations, however, these appendages are not immune to the risk of encouraging the state to assert jurisdiction over them.

FINANCIAL FLEXIBILITY

While state controls on financing, purchasing, and using research equipment are important concerns, many public colleges and universities find that their ability to acquire and manage equipment depends additionally on the degree of financial flexibility granted them under state law and regulations. State universities, for example, may have difficulty transferring funds between budget categories (e.g., personnel, capital, operations) to take advantage of opportunities such as participation in pooled equipment funds. They may be unable to carry over unexpended funds from one budget period to the next. Many state universities are not permitted to pay matching costs for equipment from tuition income or patient fees and so draw on gift funds or advance unrestricted funds.

Financial Control Practices

Financial control practices have been assessed[3] in terms of institutional autonomy and grouped into two models: the state agency model and the corporate/free market model.

Key features of the state agency model are as follows:

- All funds (from federal and private sources as well as the state) flow through the state treasury and must be reappropriated by the legislature.
- All procurements are subject to standardized requirements and centralized processing.
- Detailed spending requests focus on objects of expenditure. Deviations from budgets must be approved in advance and reported.
- Unexpended funds are returned to the state treasury.
- Changes with long-term fiscal impact are monitored.
- Purchasing, construction, and other costs of operations flow through the state government.
- Oversight is focused on process (adherence to regulations) as opposed to product (quality of research and education).

Other features may include state control of indirect cost recoveries from the federal government and restrictions on the disposition of state-owned surplus property. Indirect costs are commonly collected by the state and reallocated to the schools to a degree that varies by state. In many state universities, equipment purchased with federal funds becomes state property after title has been given to the university and is then subject to all of the arcane regulations for state property.

Key features of the corporate/free market model are as follows:

- Institutions have complete control of funds, whatever the source, including indirect cost recoveries.
- State appropriations are made in block form, and the institution has unbridled authority to contract for goods and services from outside sources.
- Oversight is focused on product as opposed to process.
- Auxiliary organizations and support activities are not subjected to state controls.

A recent study[4] examined the financial flexibility of 88 Ph.D.-granting public universities in 49 states in terms of the characteristics of these models. The results showed no differences in administrative costs, salaries, or complexity that correlate with the degree of state oversight. Differences were associated rather with the size of the university, the presence of a medical/hospital complex, graduate enrollment, unionization, and level of state funding.

More importantly, public universities with greater degrees of autonomy tend to depend less on state appropriations and to raise more of their support from other sources, federal and private. This finding suggests that relief from state regulations frees faculty and administrators to turn their attention to more productive work, including development and sponsored research activities, investment strategies, and long-range financial planning (fostered by biennial budgets and retention of unexpended balances).[5] Improvements in these areas can directly benefit the capacity of public universities to acquire and manage scientific equipment.

Deregulation in Kentucky

The state of Kentucky deregulated its institutions of higher education in 1982, with significant benefits.[6] Kentucky had been a "strong governor" state with centralized accounting and procurement for all of higher education. The state commissioned an independent study that concluded in part that state regulation was a significant barrier to effective management of the schools because of frequent duplication of procedures. The study led to the passage of the Universities Management Bill (H.B. 622). The bill afforded changes in regulation of purchasing, capital construction, accounting and auditing, payroll, and affiliated corporations and foundations. Each school was given the option of implementing any or all of the provisions of H.B. 622.

The primary effect of the bill was decentralization of the administration of higher education, enabling the schools to manage their own affairs. The move has produced significant savings for both the universities and the state by eliminating duplication and freeing administrators for more productive work.

The University of Kentucky, for example, estimates that it will save $500,000 per year by handling the purchasing function itself; $90,000 of the savings comes simply from being able to avoid the state stores' 9 percent markup. By assuming the responsibility for capital construction, the university sharply reduced the time required to appoint architects and award contracts; it awarded $7 million in contracts between July 15, 1982, and March 1983 with an estimated saving of $445,000 resulting from the streamlined procedures. Smaller public institutions that do not have sufficient administrative staff and resources to exploit the provisions of H.B. 622 on their own are forming consortia to do so.

Failure of schools to comply with the provisions of the act once they elect to follow it, or lack of cooperation among schools, could jeopardize the changes brought by H.B. 622. During the first two years under the act, however, the results were very favorable. Depending on local circumstances--the number and size of public colleges and universities and the degree of centralization--deregulation as practiced in Kentucky could be beneficial in other states.

RECOMMENDATIONS

The conflict in the roles played by state governments vis-a-vis academic research equipment is inherent to a degree in the relationship between the states and their public colleges and universities. Nevertheless, we believe that in many cases the states could combine their broad roles as funder and regulator more rationally and could otherwise help to ease the schools' serious problems with research equipment.

We recommend...

1. **That states assess the adequacy of their direct support for scientific equipment in their public and private universities and colleges relative to support from other sources and the stature of their schools in the sciences and engineering.** The states cannot displace the federal government as the major funder of academic research equipment, but judicious increases, on a highly selective basis, could be extremely beneficial to the scientific stature of states while simultaneously increasing the effectiveness of funds available from federal and industrial sources.

2. **That states grant their public universities and colleges greater flexibility in handling funds.** Desirable provisions would permit schools to transfer funds among budget categories, for example, and to carry funds forward from one fiscal period to the

next. Greater flexibility would not only improve the universities' ability to deal with the problems of research equipment, it would also be likely to provide direct savings in purchasing and would free academic administrators to discharge their responsibilities more efficiently.

3. **That states examine the use of their taxing powers to foster academic research and modernization of research equipment.** Tax benefits available under the federal Internal Revenue Code are also available in 34 states whose tax codes automatically follow the federal code. Relatively few states, however, have adopted tax benefits designed to fit their particular circumstances.

4. **That states revise their controls on procurement to recognize the unusual nature of scientific equipment and its importance to the research capability of universities.** Scientific equipment often is highly specialized. Instruments that have the same general specifications but are made by different vendors, for example, may have significantly different capabilities. The differences, furthermore, may be discernible only by experts in the use of the equipment. Desirable revisions in state controls would exempt research equipment from purchasing requirements designed for generic equipment and supplies, such as batteries and cleaning materials; would vest purchasing authority for research equipment in individual colleges and universities; and would not apply rules beyond those already mandated by the federal government.

5. **That states consider revising their controls on debt financing of scientific equipment at public colleges and universities to permit debt financing of equipment not part of construction projects, recognize the relatively short useful life of scientific instruments, and relieve the one- and two-year limits on the duration of leases.**

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3

The Universities' Role in the Acquisition and Management of Research Equipment

INTRODUCTION

The universities' involvement with scientific equipment entails many activities in addition to the conduct of research. Broadly, universities provide the administrative and physical infrastructure needed to support research that warrants the acquisition of instruments and other equipment. More specifically, in varying degree, the universities provide money for equipment from their own resources, from gifts they solicit, and from various forms of debt financing; handle the purchasing process; pay part or all of the costs of operation and repair; maintain inventories; help to optimize the sharing of equipment; and handle disposal of equipment no longer useful or needed.

The universities' approach to these functions is conditioned by characteristics unique to themselves. Usually they perceive that their primary duty is to personnel--students and the faculty needed to teach them. Also, authority in U.S. universities is highly decentralized to foster the freedom of inquiry deemed essential to first-rate research and teaching. The majority of support for academic research and the associated equipment is obtained through competitive proposals prepared by individual faculty members or small teams of investigators. Systematic programs planned well in advance are the exception, not the rule. Much of this support comes from federal agencies, so universities must use and account for equipment in accordance with federal regulations. State universities in addition must comply with state regulations.

These and other characteristics of universities and their research call for procedures in acquiring and managing scientific equipment that generally differ from practice in industry and government. In this chapter we assess academic practice, identify opportunities for improvement, and consider industrial and governmental procedures that might be relevant to academe.

ACQUISITION OF RESEARCH EQUIPMENT

Sources of Funds

Funds for academic research equipment come from the federal government, from the universities themselves, from state governments, and from business and other private sources (state funds are rarely available to private universities). The contributions of each are indicated by the NSF National Survey of Academic Research Instruments, which covers major instrumentation systems in use in 1982-1983.* The data show that federal agencies funded 54 percent of the cost of acquiring these systems, universities 32 percent, state governments 5 percent, business 4 percent, and other sources 5 percent (Table 3, Chapter 2). Other NSF data show that nearly two-thirds (63 percent) of expenditures for academic research equipment in 1983 was funded by federal agencies (Appendix B).

Funds supplied by universities may involve some form of debt financing, which is covered in Chapter 4. Also, the Economic Recovery Tax Act of 1981 permits companies to take special tax deductions for scientific equipment they donate to universities; Chapter 5 includes guidelines for universities that wish to develop a strategy for obtaining such donations.

Competitive Proposals

Private and public universities alike rely principally on competitive proposals, subject to some form of peer review, to obtain funds for research equipment. The decision to compete for funds is made by the scientist who wishes to do the research, and the outcome of competition for federal funds cannot usually be predicted with confidence. A matching contribution toward equipment may be expected from the university (see later discussion), but usually it is insufficient without additional resources from a grant, contract, or gift.

If the equipment costs more than can reasonably be expected in a normal research-grant budget, scientists usually seek supplemental funds from the department, college, or university, from other funding agencies, and from colleagues who have grant money available and need access to the equipment.

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*Systems in use in these years may have been purchased in earlier years.

Scientists with common interests join forces voluntarily to seek funds for equipment at most of the universities we studied. Such cooperative efforts may involve faculty in different departments and even in neighboring universities. Funding agencies support these joint efforts because of the quality of the collaborating faculty; further, each collaborator has apparatus and techniques that augment the shared equipment. This mode of operation is common, for example, at the Materials Research Laboratories supported by the National Science Foundation.

Several scientists with common interests and needs may be able to obtain support for shared instrument facilities outside the normal single-investigator research-grant process. NIH, NSF, DOD, and DOE all have instrumentation programs that encourage or require sharing by several qualified scientists. These programs often encourage or mandate a university contribution to the cost of the equipment (see Chapter 1).

The normal goal of a competitive instrument-acquisition effort is to win sufficient funds to buy the basic instrument after university contributions and vendor discounts have been exercised to the limit. Desirable features missing from the basic instrument are acquired through funding efforts in subsequent years. Often, however, buying the complete package is much more economical than having components installed later in the field. If the saving is obvious, the federal agency and the university may supplement their funding awards to achieve the overall economy.

We found that scientists recognize these efforts to win grant funds, pool resources with colleagues, and convince department heads and deans of the value of a university contribution as normal and necessary procedures for obtaining research equipment.

Start-Up Costs

The competitive grant system does not provide funds for equipment that must be acquired for newly hired faculty members. Most universities we contacted bear some such start-up costs, and these costs for laboratory scientists can require major financial commitments by universities. They may consume reserves equal to the endowment needed to support a faculty salary permanently.[1] Several universities queried estimated instrumentation start-up costs at $25,000 to $250,000, depending on the faculty member's discipline and academic level. Even higher costs may be entailed by hiring faculty already established as outstanding investigators. A major eastern university we visited incurred initial costs of about $2 million when it hired an established professor of chemistry.

High initial costs of equipment have discouraged universities from entering certain research areas, such as work involving synchrotron radiation, which is now available only at national shared facilities. Universities also have hesitated to enter fields where equipment is too costly to obtain for one investigator and is not readily shared because of problems such as contamination in some kinds of analytical chemical apparatus.

A specific example of the exclusion of universities from research by high start-up costs is molecular beam epitaxy (MBE), a means of growing new types of materials that can be controlled at the atomic scale. MBE is producing exciting new physics (e.g., the fractional quantum Hall effect) and promises to produce new types of semiconductor devices and very high speed transistors. A number of industrial laboratories are working with MBE, but the cost of the equipment--up to $1 million--has barred all but a few universities from research in this field.

Raising start-up funds typically involves departmental, college, and universitywide administrators. Funds are drawn from operating budgets and augmented by endowments, gifts, and flexible resources such as the NIH Biomedical Research Support Grant. The American Chemical Society's Petroleum Research Fund, the Sloan Foundation, EXXON's Centennial Engineering Education Program, Atlantic Richfield's Aid to Education Grants, and the recent NSF Presidential Young Investigator awards help cover start-up costs in certain fields. The NIH Research Career Development Award covers salary and thus helps with initial costs, since salary, as well as the costs of laboratory facilities, usually is the responsibility of the university.

Methods of allocating funds for faculty start-ups will vary with the organization of the university, but faculty involvement can help by supplying an understanding of the special needs of the research community. At a midwestern university we visited, the task is handled by a board of eight senior faculty members. The board allocates about $2.5 million per year to faculty in research support. (The university spent $96 million for separately budgeted R&D in 1982.) A significant portion of this amount is used to acquire equipment, and departments may apply to the board for start-up funding for new faculty.

Matching Funds

Federal agencies that award funds for research equipment may expect or require the university to make a matching contribution toward the total cost (see Chapter 1). Such matching is distinct from the cost-sharing arrangements in which universities pay part of the operating costs of a research project. Matching funds play a supporting rather than a leadership role in decisions to compete for grants, since the university makes the award only if the scientist wins the competition.

Many state universities are not permitted to pay matching costs from instructional monies. Instead, they draw on gift funds or advance unrestricted funds. Gift funds are used also to pay start-up costs for new faculty, and private donors may be willing to give matching funds because of their added leverage.

Several universities told us they had raised matching funds from donors and philanthropic trusts. The added leverage and the appeal of some current technology help scientific equipment to compete with other would-be beneficiaries, such as athletic programs and hospitals. Several universities also cited the efficacy of fund drives for specific items of research equipment.

Decisions on providing matching funds are made differently among universities. At some small universities that have little flexibility in departmental or college operating budgets, the chief executive officer makes decisions on matching (as well as start-up funding). In other cases, the deans make such decisions and often delegate budget planning to the departments so the decisions reflect departmental priorities. At some universities, a faculty committee allocates the available funds.

Attitudes toward matching also vary. Some universities voluntarily offer matching on all major instrument proposals in the hope that it will improve their competitive stance. Other universities pursue more conservative practice by matching only when it is a condition of receiving an award. We encountered some instances where matching funds were so scarce that faculty did not seek grants known to have a mandatory matching requirement.

From the faculty perspective, the major reason for an institution to provide matching funds is to acquire the equipment and pursue the research described in the proposal. Faculty also perceive that financial endorsement by the university may make a proposal more competitive. As implied above, however, some universities would rather use discretionary funds in other ways, Also, universities often are not certain that matching funds are necessary to obtain the grant; they see a need for greater clarity in agencies' statements of their matching requirements.

Multiyear Payment

When the outright cost of a piece of equipment is more than the funding agency can accommodate in one year, an investigator may request an advance against the university's future-year capital funds. We encountered a few instances where the sponsoring agency had approved a proposal to buy an instrument with funds advanced by the university and recovered by charging annual installments to the grant as direct costs. The interest foregone is not recoverable by the university as a direct or indirect cost. While the agency may agree to the principle of the plan, it does not guarantee future-year funding. Thus the university subsidizes the purchase and assumes significant risk. The burden of negotiation is also substantial for everyone involved, and the method is not widely used.

Another way to obtain equipment before the full purchase price is in hand is to combine funds from two successive years. With first-year funds secured and second-year funds promised, the university may be able to deal with vendors so that payment can be spread over several years without finance charges. We found that scientists at some universities make such arrangements without help from university officials. Faculty members said they would like to be able to do so more formally by putting half the cost of a piece of equipment in each of two years of a proposal. We are not aware of prohibitions against combining funds from successive grants, but the perception is that agency officials are not sympathetic to such arrangements.

When vendor and scientist enjoy mutual trust and confidence, some vendors have agreed to multiple-year payment plans without formal leasing and without interest charges. This practice is costly to the vendor, but it may help to consummate a sale.

Leasing

Leasing is a standard way to spread payment for equipment over several years. We found, however, that principal investigators prefer to find ways of obtaining apparatus without resorting to leasing because the ensuing costs reduce flexibility in future years of research by obligating grant funds to cover lease costs. Carrying charges are high (typically above prime rate), and the vendor is less aggressive in discounting if a lease must be arranged. Further, leasing, like other kinds of debt financing, is practical only when income is available to meet the payment (see Chapter 4). Although universities commonly lease equipment such as copying machines and computers, they lease only a very small fraction of research instruments.

Lease payments, in contrast to equipment purchases, are normally charged with indirect costs. This further increases the costs of leasing to awards, relative to direct purchase, by a percentage equal to the indirect cost rate. Some universities, however, have dealt with this problem by not charging indirect costs on leased equipment. Excluding such payments from the indirect cost base requires negotiations with the auditors.

Many states forbid multiyear leases unless a nonstate source provides the payments; some state schools have created foundations designed to overcome this and other regulatory barriers. At Georgia Tech, for example, multiyear leases are handled by the Georgia Tech Research Corporation (GTRC), a private, not-for-profit entity. All external research funds at Georgia Tech, except funds provided by law, are awarded to GTRC, which also retains part of the indirect cost funds generated in research projects. GTRC in part buys and leases equipment and provides it to individual research programs. This procedure permits Tech to get research equipment into the laboratory of the individual faculty investigator more quickly, to return obsolete equipment and replace it by newer models, and to spread equipment costs over multiple years.

We cite two other examples of leasing that we encountered. One involved a 500 MHz nuclear magnetic resonance (NMR) spectrometer acquired through a lease with an option to purchase because the funding agency would provide only $138,000 per year toward the acquisition of the equipment (an NMR of this kind typically costs about $750,000 fully equipped). The second example was a similar experience in the acquisition of a mass spectrometer and an NMR spectrometer.

The corporate laboratories we visited preferred purchasing over leasing because businesses receive tax benefits from research investments and from depreciation allowances on purchased equipment. They did lease some research equipment, such as NMR and mass spectrometers and computer equipment when it was being evaluated for long-term use.

One national laboratory indicated that lease to ownership is an accepted approach when capital funds are unavailable. The primary consideration in selecting the financing method is the interest charge. Another national laboratory did a lease versus purchase analysis for a computer. With direct purchase defined as 1.0, the other cost ratios were as follows: lease 2.01, lease with option to purchase 1.18, third-party lease to ownership 1.17, and lease from vendor to ownership 1.40. Such analyses are valuable and are done by many universities when they are considering leasing equipment.

The Purchasing Process

Universities' purchasing procedures should help scientists obtain reliable, quality equipment in a timely and economical manner. For purchasing procedures to work most effectively, purchasing agents and research faculty must understand each others' needs. Misunderstanding can lead to delays in acquiring equipment, which can result in higher prices and can also severely hamper research.

When buying federally funded equipment, universities must comply with federal acquisition policies prescribed particularly by OMB Circular A-110, Attachment O, for grants, and the Federal Acquisition Regulation for contracts (see Chapter 1). State universities additionally must comply with state purchasing regulations (see Chapter 2). State regulations often are more restrictive than the federal regulations, and private universities generally enjoy substantially greater flexibility than public universities in purchasing scientific equipment.

Purchasing agents can be extremely helpful in the acquisition process. Creative and aggressive purchasing agents can negotiate volume discounts and payment alternatives that provide substantial savings on grants and contracts. We were told of universities that have purchasing agents knowledgeable and concerned about the issues involved in acquiring scientific equipment. Many faculty members at other schools, however, indicated that uninformed purchasing agents are a significant problem. The North Carolina Board of Science and Technology recommended in December 1983 that the state purchasing organization arrange continuing education programs for state purchasing agents who handle scientific equipment and assign an existing purchasing agent to specialize in scientific equipment; the board recommended also that public institutions make a special effort to educate faculty in purchasing procedures for equipment.

MANAGEMENT OF RESEARCH EQUIPMENT

We examined academic management practice in budgeting and planning for research equipment as well as in operation and maintenance, inventory systems, and replacement and disposition. The nature of universities--their decentralized organization and unique system of shared governance--doubtless impedes orderly management in the corporate style. Still, we observed that some practices on campus clearly ease problems with equipment more effectively than others, so greater attention to management would seem to be in order. Our findings indicate that universities would benefit from stronger efforts to improve their internal communications. Public universities are obliged by state regulations to deal with equipment-management matters that do not normally concern private universities; these additional complications are covered in Chapter 2.

Budgeting and Planning

Budgeting and planning in industry and in universities differ significantly. In industry, budgeting and planning often start several months (or years) before the year in which expenditures are to be made; industrial laboratories have reasonable control of funding, planning, and scheduling, subject only to corporate strategies and decisions. Universities are differently situated. Although they routinely plan instructional programs in advance of the academic year and capital building programs several years in advance, most of their scientific equipment is funded from competitive grants and so is not readily amenable to planning. While the competition is deemed necessary to assure that the best research is supported, barriers to planning are inherent in the system of competitive proposals.

Usually the outcome of a grant proposal is not known until a few weeks before the research is started. Some agencies, in fact, are unable to meet grant renewal and award deadlines, and universities often take risks by carrying minimum costs to keep a research team together while awaiting the final terms of an award. The short term (seldom more than three years) of grants and contracts also makes planning difficult. Further, the individual researcher is always subject to congressional or agency decisions on the continuation and level of funding of federal programs. Investigators at several schools cited decisions by federal agencies, as a result of congressional cuts, that required significant changes in plans to acquire new equipment as well as in management practices for existing equipment.

The larger block grants, such as NIH program project grants and grants to NSF regional and national facilities, offer more opportunity for planning (see Chapter 1). The involvement of more scientists with a common purpose, a strong incentive for sharing, and longer term (five year) awards all encourage planning. Several universities cited such core support grants as particularly useful in providing stability, permitting some mid-term planning, and addressing the equipment problem in an orderly fashion.

Universities appear to be increasing their attempts to formalize equipment funding processes with faculty involvement in allocation of university resources. Two universities told us of internal capital funding and resource allocation boards that attempt to identify specific needs for capital equipment and plan to meet them. No university, however, described a process as long or as detailed as those in national laboratories or in industry.

One industrial department head described a model designed to calculate the costs of equipping a typical engineer with capital items. The model does not consider inflation or equipment upgrade, but does provide for replacing equipment after three years; it calculated start-up cost at $145,000 to $160,000 per engineer. The model was described as having several advantages: it eased the calculation of equipment requirements; once accepted, it made funding for capital equipment easier to obtain from higher management; and it aided both morale and productivity. We found no university that can exercise similar control over funding for research equipment. We feel that most universities, however, can better organize their procedures for supplying matching funds and establish clear criteria for allocation of such funds.

Investment in People

Universities, if forced to choose, generally will use available funds to retain faculty and graduate students in preference to buying equipment. This attitude is in keeping with the schools' dual mission--education and research—which emphasizes people and requires the long view. To build, or to rebuild, a faculty takes decades. Industrial laboratories tend to be more ready to lay off personnel, despite the potential impact on their capabilities, and will invest in automating research equipment. Automation is not as essential in universities, where graduate students change samples over nights and weekends. Universities report risking funds to keep research teams together for a time between grants in the hope that support for them will materialize; the funds so invested are invariably for personnel, so equipment budgets may be sacrificed to keep a team intact.

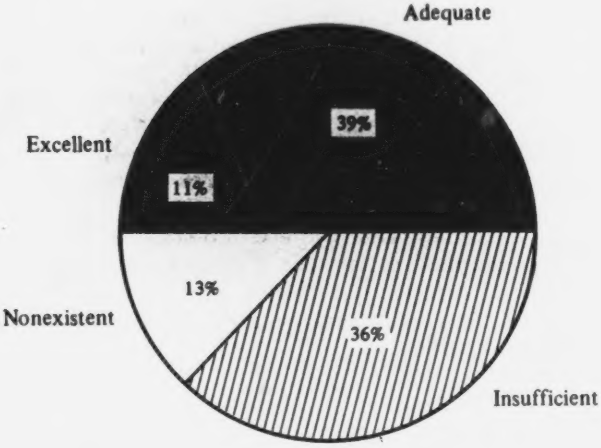
Operation and Maintenance of Research Equipment

Operation and maintenance of academic research equipment are serious management issues at every university we visited. Some universities do an excellent job of keeping research equipment in good repair and have qualified staff to operate it when appropriate; others leave much to be desired. All find the task a strain on their resources.

The NSF instrument survey included a departmental/facility assessment of instrumentation support services. Some 49 percent said their services were inadequate or nonexistent, 39 percent said they were adequate, while only 11 percent said they were excellent (Figure 6).

Another survey, submitted to the National Science Board, indicated that 72 percent of the respondents relied primarily on

FIGURE 6
Department/Facility Assessment of
Instrumentation Support Services
1982-1983



SOURCE: Division of Science Resources Studies, National Science Foundation.

departmental support services (computer and other electronic repairs, glass shop, machine shop, mechanical shop, other general repairs, etc.).[2] The usage of support services was higher in public than in private universities.

Over the service life of equipment, total operating and maintenance costs will frequently exceed the purchase costs. One of the NSF Materials Research Laboratories has found over the years that operation and maintenance of its central facilities cost about 1.5 times the amount it spends in the same year on new equipment. NSF data on departments/facilities show that about 15 percent of annual instrumentation-related expenditures in 1982-1983 were devoted to maintenance and repair (Table 5).

We encountered many cases where universities had to decline gifts of research equipment because they could not afford to operate it. One university, for example, declined a gift of computer-aided design equipment because it would have cost $170,000 per year to operate.

Recognition of Costs

Not all university administrators appreciate the high costs of maintaining and operating research equipment, nor do they budget for them. One state university, for example, received $10 million over five years from the state government to purchase equipment (not all was used for research equipment; some went for teaching apparatus). Adequate funds for maintenance and operation were not available in the university's budget, even when the equipment was used for teaching, nor was the faculty attracting sufficient grant money to meet these costs. In consequence, much of the equipment is not regularly available for use.

Technical Support Staff

Technical support staff is an important issue. Many academic departments traditionally have not used research technicians; rather, the practice has been for graduate and postdoctoral students to work with faculty repairing equipment, often at considerable expenditure of time. While some of this activity is educational, a great deal of it is not and distracts effort from research. In any event, as research equipment becomes more sophisticated, more permanent technical support people become necessary. It can be difficult, however, to attract competent support people to universities. They are usually less well paid than in industry and do not find the same attractions at a university as the faculty do. Small numbers of faculty frequently

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TABLE 5 Instrumentation-Related Expenditures in Academic Departments and Facilities in 1982-1983, by Field (Dollars in Millions)

	Total	Purchase of Research Equipment $500 or more	Purchase of Research-Related Computer Services	Maintenance/ Repair of Research Equipment[a]
Total, Selected Fields	$640.6 (100%)	$414.5 (65%)	$121.3 (19%)	$104.8 (16%)
Agricultural Sci.	40.6 (100%)	28.4 (70%)	7.3 (18%)	5.0 (12%)
Biological Sci., Total	192.3 (100%)	132.4 (69%)	27.8 (14%)	32.2 (17%)
Graduate Schools	79.0 (100%)	51.8 (66%)	13.2 (17%)	14.0 (18%)
Medical Schools	113.3 (100%)	80.5 (71%)	14.5 (13%)	18.3 (16%)
Environmental Sci.	49.6 (100%)	33.4 (67%)	6.9 (14%)	9.3 (19%)
Physical Sci.	151.3 (100%)	91.2 (60%)	31.9 (21%)	28.2 (19%)
Engineering	146.6 (100%)	86.5 (59%)	41.3 (28%)	18.8 (13%)
Computer Sci.	29.7 (100%)	19.7 (66%)	3.6 (12%)	6.4 (21%)
Materials Sci.	12.4 (100%)	9.6 (77%)	0.6 (4%)	2.3 (18%)
Interdisciplinary, not elsewhere classified	17.8 (100%)	13.3 (75%)	1.9 (11%)	2.6 (14%)

[a] Estimates encompass expenditures for service contracts, field service, salaries of maintenance/repair personnel, and other direct costs of supplies, equipment, and facilities for servicing of research instruments.

NOTE: Sum of percents may not equal 100 percent because of rounding.

SOURCE: National Science Foundation, National Survey of Academic Research Instruments and Instrumentation Needs.

allocate the cost of a technician's salary among their grants, but grant or contract funds are often so uncertain as to bar long-term career stability for technicians. The block funding and centralized operations of the NSF Materials Research Laboratories are an excellent solution to this problem for research that can be funded in this mode.

User Charges

It is common practice to attempt to cover the salaries of equipment-support personnel and the costs of operation and maintenance through user charges. The amount of use is often hard to predict, however—new facilities often require some time to reach a full level of use--which makes it difficult to set appropriate rates. High user fees tend to reduce the use of equipment and can actually reduce total income to the facility and make it available only to the best funded potential users. We heard frequently that user fees considered optimal by the people running the facility do not cover the costs of operation. We rarely found that user fees paid the operating costs of shared, central-facility research equipment. The NSF-supported Materials Research Laboratories have much experience with this type of operation; typically, they find it necessary to subsidize 20 to 30 percent of the operating and maintenance costs of their central facilities from core grants.

Regulatory Issues

A general difficulty with user charges is that what is true at one institution is not necessarily true at another, although both are operating under the same federal regulations. The problem lies in the inconsistent and often conservative interpretation of the regulations by both federal and academic officials (see Chapter 1).

Specifically, we encountered a faculty member at one university who had been able to charge his various research grants in advance for access to research equipment, and so knew at the beginning of the operating period that the full operating costs would be covered. When a similar prepayment or subscription plan for instrument use was tried at another university, the federal auditors would not allow it. Whether the difference was due to a substantive difference of process (of which we are unaware) or to the way the plan was explained to the auditors, we were unable to ascertain.

OMB Circular A-21 prohibits providing use of equipment to anyone at lower cost than to government grants or contracts. This prohibition often interferes with maximum use of equipment--it is not possible, for example, to provide low cost or free use of research equipment for instructional purposes while billing federal grants and contracts at a higher rate (low rates can be charged during low-use periods, such as from midnight until 6 A.M., so long as all users are treated equally). One university pointed out a common solution to this problem for computing centers. Like every other academic computer center we encountered, the one at this school required a university subsidy to break even. The university budgeted this subsidy as an allocation to users who could not afford the full rates, rather than applying it to an across-the-board reduction of rates.

Physical Infrastructure

The operation and maintenance of research equipment depend on the physical infrastructure for research. The infrastructure includes fume hoods, electrical supply and insulation, sound isolation, air conditioning, numerous kinds of support equipment, such as oscilloscopes, leak detectors, and machine tools (e.g., lathes and milling machines), service and maintenance facilities, as well as the buildings that house research laboratories.

We saw many 1950s vintage oscilloscopes at universities and relatively few modern ones; most of the machine tools in universities were acquired well over 20 years ago, often as surplus, and are at the point of needing replacement. When funds are scarce, federal agencies tend to support equipment that will be used directly in the research they fund; the less glamorous items are essential, but not as easy to find support for. Federal agencies once funded this kind of equipment but no longer support its inclusion in project budgets. The universities might buy it and recover a portion of the costs attributable to organized research through the indirect cost pool, but universities are under intense pressure to hold down indirect costs. Also, cost recovery takes 15 years at the federal use allowance of 6 2/3 percent per year.

University Maintenance Facilities

None of the universities we visited had the service and maintenance infrastructure found in most large government and industrial laboratories. Many faculty expressed the desire for some university facility to maintain research equipment, but we found successful examples of such facilities to be rare. The one universitywide facility that seems to work well is Iowa State's REAP program (see discussion below under Optimization of Use).

We think there may be several reasons for this situation. Where individual research grants pay most of the costs through user charges, the uncertainty of income is a barrier. A university is not typically a geographically focused enterprise, so a central maintenance facility may be practical at some institutions and not at others. Also, the increasing complexity and specialization of research equipment means that service people must be correspondingly specialized. The result is a greater tendency to rely on manufacturers' service representatives. This solution may be best in large urban areas; in more isolated areas, faculty may have to service the equipment themselves or rely on university resources. University-subsidized facilities can relieve individual faculty and departments of financial responsibility they may have difficulty meeting.

Service Contracts

Service contracts for most research equipment usually cost about 10 percent of the purchase price per year. When equipment is shared among a small number of faculty and research grants, it is common practice to allocate the costs of a maintenance contract. We learned at some universities, however, that investigators could not afford service contracts on equipment and were gambling that costly service would not be needed. Some manufacturers will give discounts on service contracts if a university issues a purchase order for servicing all its equipment on the campus; we learned of discounts on the order of 20 percent. Manufacturers also may give discounts for payment at the beginning rather than the end of the service year; in one instance the discount was 10 percent.

Inventory Systems

A reliable inventory of university-purchased research equipment can be used to ensure proper recovery of indirect costs (see Chapter 1). Many of the universities we studied had paid little attention to inventory systems; most have just developed or are still developing such systems. Several academic administrators reported that their inventory systems were used to screen purchase orders and avoid duplication, but it was not clear that this application was useful. Only one university we visited, Iowa State, routinely uses an inventory system to facilitate sharing of equipment (see section below on Optimization of Use).

The REAP inventory includes only 3 percent of Iowa State's general inventory. The other university inventory systems we learned about included all equipment capitalized (commonly at $500 or more) and were very expensive to implement. One university, for example, has been working for two years to set up a system at a cost of more than $200,000; the provost estimates a steady state operating cost of $100,000 per year. A second inventory system requires eight full-time employees in steady state and is highly automated, with a bar-code label on all property. When fringe benefits and overhead are added to salaries, the cost is about $350,000 per year, plus computer time. A third institution estimates a cost of about $10,000 per month just to maintain the data base and thinks it would be prohibitively expensive to develop a system useful for facilitating sharing of research equipment.

These inventory systems are compiled by nontechnical people and do not contain the information scientists must have about equipment to assess its utility. Except at Iowa State, all faculty we asked had only negative comments about the use of inventories to promote sharing.

National Laboratory Systems

The two national laboratories we queried have developed effective inventory systems that contain information on the capabilities and current state of repair of equipment. Data are entered by scientifically trained people. Staff scientists can call up the inventories on their computer terminals, and they are useful in promoting sharing of equipment. The labs also have used their inventories to argue for the replacement of old equipment, and managers felt this information was instrumental in persuading Congress to fund the Department of Energy Utilities and Equipment Restoration, Replacement, and Upgrade Program (see the following section on Replacement and Disposition).

Replacement and Disposition of Research Equipment

Replacement of research equipment with state-of-the-art models, and disposition of worn or unneeded equipment, also are significant management problems in universities. Replacement is extremely costly: data from the NSF instrument survey indicate that equipment in use in 1982-1983 has a replacement cost today that is about 50 percent greater than its original acquisition cost. Further, inadequate disposition procedures can hamper optimum use of equipment and entail costs that might be avoided.

Universities, as we have seen, do not plan their purchases of research equipment in the same way that government or industry does. They have no programs like the DOE Utilities and Equipment Restoration, Replacement, and Upgrade Program, which has been funding replacement of poor and inadequate equipment in defense-related national laboratories since 1982. Sandia, Los Alamos, and Lawrence Livermore national laboratories, for example, will receive about $434.9 million through this program, which is projected to end in 1988. Many industrial laboratories also replace scientific equipment systematically. For reasons of obsolescence and taxes, they depreciate equipment on an accelerated basis and often replace it as soon as it has been fully depreciated, even if it is still useful.

Universities face difficulties in orderly replacement and modernization of research equipment. They pay no taxes and so gain no tax advantages by depreciating equipment. They can collect a use allowance (6 2/3 percent per year), or depreciation (at a higher, negotiated rate) over the useful life of the equipment, as an indirect cost of research under OMB Circular A-21, but both faculty and funding agencies are exerting considerable pressure to limit indirect costs. Depreciation or the more common use allowance, moreover, can be collected only for equipment purchased with nonfederal funds and so plays no role in replacing the majority of research equipment, which is purchased with federal grant or contract funds. Furthermore, DHHS auditors interpret OMB Circular A-21 so that universities that convert from use allowance to depreciation part way through the life of equipment must then value it as if they had used the same rate of depreciation, rather than the lower use allowance, since acquiring the equipment. This requirement imposes a significant financial penalty for conversion (see Chapter 1).

Assessing user charges to amortize the replacement of equipment is rarely practical, and recovery of purchase costs is not allowed for equipment bought with government funds. We found no case where equipment purchase costs were fully recovered through user charges. One problem is that the necessary charges may be higher than most grants can support. Recovery of purchase costs is being attempted in one electron microscope facility we know of, where the user charge will be $75 an hour when the debt-service costs are included. Other electron microscopes on the campus, which recover only operating and maintenance costs, charge $35 an hour.

A further bar to systematic replacement and modernization is that investigators' needs can change rapidly as new research opportunities arise. Additionally, when faced with tight budgets, investigators tend to fund people and look for equipment in the next review cycle.

The situation is different for centralized equipment with many users and for service equipment in the university infrastructure that needs to be kept up to date. When the task involves more than the cooperative effort of a few investigators or a department, then some universitywide planning is called for. Still, we found no plans for systematic replacement of such equipment. With the present strained budgets of most universities, the problems are dealt with only when they become crises.

Disposition Issues

Among important issues in disposition is the lack of incentive to transfer equipment between investigators at the same or different universities. Some still-useful equipment is transferred informally within universities by using barter payment. One university, for example, circulates a newsletter advertising equipment that is sought or available for barter payment. Under the present system, however, faculty at most universities have no incentive to transfer equipment other than the need for space (which, like equipment, warrants careful management). Faculty have every incentive to keep equipment in case it might someday be needed again; only at Iowa State, among the schools we visited, was much equipment relinquished. This lack of incentive to transfer is a barrier to optimum use, since the equipment may be more valuable to a laboratory other than the original recipient. Agencies and academic administrators could do more to facilitate transfer of equipment from one researcher to another by means of incentives in the form of savings to the receiver and rewards to the donor.

One might imagine the transfer of useful equipment at bargain prices within or between universities. The main obstacle seems to be that such sales could result in charging the government twice for the same equipment. If allowed, the practice would yield income for activities that support the original sponsor's mission. Formalizing the procedure on a larger scale would encourage more efficient use of many items of research equipment.

Disposal procedures at universities require attention. The administrator of a large academic laboratory reported that procedures for disposing of equipment that is not needed are frequently time consuming and complicated. While questions of title and disposal are being worked out, the lab must store the equipment at a cost of $15 per square foot per year. The administrator felt that the lab's operating funds could be better spent. He cited inadequate administrative support for an efficient disposal system as a significant contributor to the problem. We learned of a case at another university where excessive administrative delay by the surplus property office prevented researchers from realizing a good price on sale of equipment.

Many universities have an administrative entity assigned to dispose of equipment that no one wants. In our investigations, it was seldom praised. The major exception is the REAP organization at Iowa State, which was highly praised for its efforts on disposal and salvage of surplus equipment.

OPTIMIZATION OF USE

Sharing Equipment

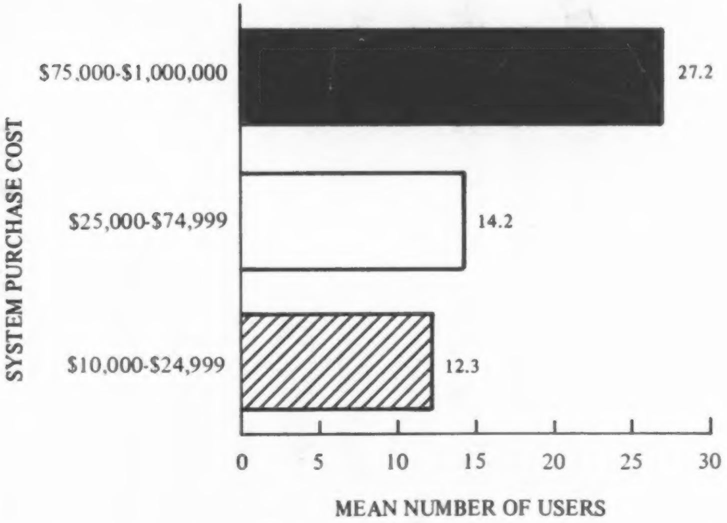
Sharing of research equipment is a straightforward way to ease equipment problems in universities and is commonly practiced. The degree of sharing that is required or is feasible, however, varies greatly among fields of research; important determinants include the cost and nature of the equipment and the characteristics of academic science.

The higher the costs of obtaining and operating a piece of equipment, the higher are the pressures to share it. Thus sharing by many users has long been characteristic of facilities in high-energy and nuclear physics and in optical and radio astronomy. The principle is evident in NSF data on academic facilities in use in 1982-1983. The mean number of users was 27 for equipment costing $75,000 to $1,000,000, 14 for equipment costing $25,000 to $74,999, and 12 for equipment costing $10,000 to $24,999 (Figure 7). The same data show that 60 percent of academic instrument systems costing $75,000 to $1,000,000 were located in shared-access facilities (Figure 8).

The nature of the research and the equipment sometimes works against sharing. The research may require modifications to equipment that make sharing impossible, or it may simply require full-time use of the equipment on one project. When apparatus is contaminated by samples, as occurs in molecular beam epitaxy machines or certain chemical analytical apparatus, for example, sharing is neither practical nor effective.

Further, the characteristics of academic science are not generally conducive to unlimited sharing of resources. While more collaboration as well as more sharing of research equipment would be desirable in some situations, emphasis on individual creativity and scholarship is essential to the vitality of the university. Creative research is frequently a solitary activity, and it often requires dedicated equipment. Professors are judged by their contributions as individuals, which tends to discourage collaborative efforts.

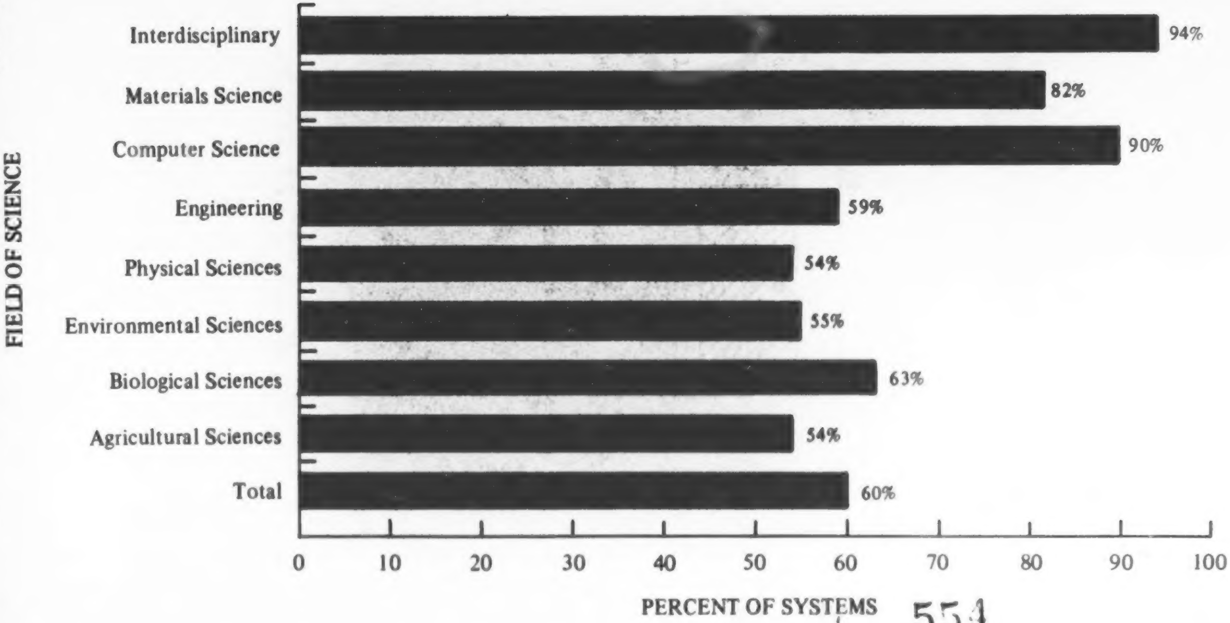
FIGURE 7
Mean Number of Instrument System Users
by Purchase Cost
1982-1983



SOURCE: Division of Science Resources Studies, National Science Foundation.

FIGURE 8

Percentage of Academic Research Instrument Systems
Costing $75,000-$1,000,000
Located in Shared-Access Facilities
1982-1983



SOURCE: Division of Science Resources Studies, National Science Foundation.

Computers, if powerful enough, are easily shared and sufficiently different from other types of research equipment that we will not consider them here in depth. The increasing power and decreasing cost of small computers act to reduce the number of users who might share a machine, and we feel that computers increasingly will be shared only by those who require the computational power of supercomputers. Methods of giving universities access to supercomputers have been addressed by the NSF Advisory Committee on Advanced Scientific Computing Resources.[3] NSF has since announced plans to fund supercomputer research centers at four universities (see Chapter 1).

We found substantial sharing of research equipment at all of the universities visited in the course of this study. The methods of sharing ranged from informal lending and borrowing of smaller, inexpensive items to operating larger items as centralized facilities.

Small pieces of equipment are frequently shared within a geographical radius determined by their portability and knowledge of their existence. Informal interaction among faculty and graduate students is the most common mechanism. It should be noted that sharing usually offers educational benefits. Students learn to use a wider variety of equipment to solve their problems and in the process have the opportunity to exchange ideas with a wider circle of people.

Sharing is very effective when the research requires limited and routine use of commercially available service-type equipment such as electron microscopes, surface analytical equipment (Auger electron or x-ray photoemission spectroscopy), and high-field nuclear magnetic resonance spectrometers. (These items cost between $100,000 and $1,000,000.) Sharing such equipment also often permits a technician to be provided to maintain and operate the equipment as well as to train students to use it.

The utility of centralized facilities is illustrated by the 14 Materials Research Laboratories currently supported by NSF through block grants to major research universities. We visited four of these labs. The grants support multi-investigator research on materials as well as central facilities incorporating the kinds of equipment noted above. We found that the Materials Research Laboratories have been effective at operating central facilities on a relatively large scale and providing an excellent educational environment for students.

In many academic departments, especially chemistry departments, centralized equipment, such as infrared, visible, and ultraviolet, NMR, EPR, and mass spectrometers, is used intermittently by a large number of researchers. Departmental laboratories at a medical school we visited were set up so that centrifuges were conveniently located for use by several research groups; we found this type of sharing in most universities.

We observed that shared instrument facilities work best when supervised by a faculty member whose research depends on them and who will insist on high-quality, up-to-date performance from the equipment. Service and repair costs increase when equipment is shared by many scientists, and a technician is usually necessary to operate it and train users; in larger centralized facilities one technician can often look after several related pieces of apparatus.

Faculty generally wish to share equipment with their colleagues, but want sufficient control to ensure that the equipment remains in optimum working order. Under these conditions, investigators often share equipment, but commonly by means of collaboration with another investigator on a problem both are pursuing.

We learned that officials at some universities encourage sharing by giving higher priority to allocation of funds for shared equipment than for nonshared equipment. We found a similar practice in industry, where equipment is frequently shared. Laboratory management at a large chemical company we visited encourages sharing by rewarding, in its research budget, a group that finds it can avoid buying equipment by sharing with another group.

The REAP Program

As noted earlier, an inventory system plays a significant role in equipment sharing at only one school we visited, Iowa State University. The university established its research equipment assistance program (REAP) in 1974 with the help of an NSF grant of $114,000. Its direct costs currently total about $123,000 per year, including salaries, computer support, and other expenses. REAP has evolved into an accepted, trusted, and helpful program in support of researchers' needs for equipment. Its components are an easily accessible, simplified, edited inventory; a diagnostic service to help maintain equipment in good working order at low cost; an apparatus stockroom that recycles, loans, and salvages equipment; and a staff who are devoted, helpful, and interested, but remain low key and nonobtrusive. A detailed report on the program appears as Appendix G, and only a brief summary will be given here.

The computerized inventory is focused on scientific instrumentation and includes only 3 percent of the university's general inventory; in June 1984, it contained almost 10,000 items (each costing at least $500 initially) having a total value of nearly $30 million. The inventory is used widely as a sharing tool; faculty are encouraged to use it to learn if a piece of equipment on campus might fit their needs. The REAP staff stands between the holder and the seeker of the apparatus, and the holder is not coerced into sharing. If the device is heavily scheduled, fragile, time consuming to use, or modified so that it is not useful to others, a "no" from the investigator is accepted without challenge. The general response, however, is an offer to share, because REAP is liked by the researchers, actively helps the faculty, and guarantees that borrowed equipment will be returned in at least as good condition as when it was loaned.

REAP maintains a storeroom of unused equipment and parts, and browsing is encouraged. The staff are knowledgeable troubleshooters and often can either repair equipment or point to the repairs necessary to avoid expensive service contracts. They are regularly sent to courses on equipment servicing to help them keep up to date.

As universities develop inventory systems, we believe that they might usefully consider the innovations found in REAP. It is clear that REAP owes much of its success to a devoted and technically competent staff, a well-designed, specialized inventory, and an academic community that takes pride in finding cost-effective solutions to problems. When a university has limited access to external repair facilities, is small enough to have institutionwide cohesiveness, and is able to attract and retain an interested and competent staff, an investment in a program like REAP seems wise.

National, Regional, and Industrial Facilities

Academic scientists also share research equipment at national and regional facilities funded by federal agencies (see Chapter 1). To a considerably lesser extent, they have access to industrial equipment.

National Facilities

National facilities involve equipment that is far too expensive--in the range of tens to hundreds of millions of dollars--to be provided exclusively to a single university. These facilities are usually associated with and managed by a university or national laboratory. Two that we visited were the Meson Physics Facility (LAMPF) operated by Los Alamos National Laboratory and the Stanford Synchrotron Radiation Laboratory (SSRL). Both are supported by DOE.

The chief management problem at national facilities is to provide access and a suitable environment for exploratory research. Beam time at SSRL, for example, is oversubscribed; time is assigned to investigators only after their requests are subjected to rigorous review, and only about half of the worthy proposals are awarded beam time. This limited beam time tends to reduce opportunities for serendipitous discovery and high-risk research. In an attempt to overcome this problem, SSRL has recently adopted the Participating Research Team (PRT) mode. A small number of consortia (with university participation in combination with industrial or government labs) set up instrumentation (which the consortium must pay for) on one of the SSRL ports; the university part of the PRT has one-third of the beam time to use as it wishes, the industry-government part has one-third, and the remaining third is allocated to the larger user community through the review process.

Regional Facilities

Regional facilities are designed to serve a smaller, local community of users. They are funded by agencies that include NSF, NIH, NASA, and DOE. While the equipment at these facilities is expensive, it would not be out of the question to buy it solely for one of the larger universities.

These facilities provide regional service with varying degrees of effectiveness.[4] Our observations suggest that when problems occur, they have two fundamental causes. First, the scientists running the facility are usually more interested in doing research than in providing service to users. Second, even given strenuous efforts to be fair, scientists at the host institution have the advantage of being there; thus a large community of local users may dominate the facility. Where a large and scientifically strong group of potential users is based at one institution, it may be better to provide a facility dedicated to that institution, instead of to regional services. In many cases, however, regional facilities have served their communities well by providing access to equipment for users who otherwise would not have such an opportunity.

The laser "lending library" (operated by scientists at the University of California-Berkeley and Stanford University) is a regional facility praised by all users. The library places a laser in an investigator's lab for a few months without charge; the sponsoring agency (NSF) pays the maintenance costs and has found them to be considerable. The regional laser facility at MIT is more conventional; the lasers are housed there and users come to them. It, too, has provided lasers to scientists who would not otherwise have had access to them. Neither of these facilities, however, is useful to investigators whose work requires long and nearly continuous access to a laser.

Industrial Facilities

Academic scientists can best gain access to state-of-the-art equipment in industrial laboratories through collaboration with industrial investigators. Such collaboration does occur frequently in pursuit of common interests, and we encountered several examples. Normally, however, industrial labs are not set up to service outside users; barriers to academic use include considerations of safety and liability and proprietary information, as well as conflicting work schedules. Industry does provide equipment for academe in other ways, sometimes involving state governments, and these mechanisms are covered in Chapters 2 and 5.

Remote Access to Research Equipment

Because research equipment increasingly is operated under computer control, it may be possible to share it by means of remote access. Such access might also reduce the time and expense of travel to some regional or national facilities. In the future, high data-rate transmission (at 52 Kbaud, for example) from the instrument to the user via satellite down-link will be inexpensive, as will high-resolution computer graphics. User-to-instrument communication at 1,200 baud now exists, is comparatively cheap, and should be adequate for issuing most commands. (Computing equipment--generally excluded from this discussion of sharing--is widely used by remote access.)

One case that we encountered suggests the potential of remote access. Some students and a professor in the chemistry department at Duke University set up a link between a small microcomputer, their obsolete departmental nuclear magnetic resonance (NMR) spectrometer, and a modern NMR at Research Triangle Park, 15 miles away. A user at Duke was able to operate the remote instrument as if seated at its console. This experimental study began in 1981 and employs specially designed software. We think the idea might be applicable to a limited number of other instruments in situations where the investigator need not have intimate contact with samples after they are prepared and they could be delivered by messenger. As computer networking grows and universities upgrade their telephone systems and install optical fiber communications links, opportunities for remote access to equipment, even on individual campuses, might expand significantly.

Remote control of telescopes is now a fact at large observatories; and communications technology can extend the link between telescope and control room from tens of feet to thousands of miles.[5] Kitt Peak National Observatory, for example, is now scheduling remote observations. Within the limitations imposed by the relatively slow telephone data rate (one acquisition TV frame every 30 seconds, and one terminal graphics display every 10 seconds), the observing runs thus far have proved quite successful.

STRATEGIC PLANNING

The costs and complexities of acquiring and managing first-rate academic research equipment are some of the several pressures, mainly financial, that appear to be moving universities toward campuswide strategic planning.[6,7] Such planning in part leads to preferential allocation of resources to disciplines that offer the university the best opportunities to achieve distinction. A university might allocate minimal resources to some departments, or even close them, for example, in order to provide better research facilities for others. We believe that more hard decisions of this kind will have to be made, but keeping in mind that universities work on a much longer time scale than most of our society. Sound strategic planning must involve faculty participation, but clearly requires more centralized decision making than is now common in academe.

RECOMMENDATIONS

The universities' ability to acquire and manage research equipment efficiently reflects factors that include individual circumstances, decentralized authority, the project-grant system that funds much of the equipment, and state and federal regulations. Within this context, however, we have identified a number of management practices that are effective and warrant more widespread use. These practices form the basis of the recommendations that follow.

The recommendations on the whole imply a need for universities individually to consider a more centralized approach than is now the general practice in their management of research equipment. We note that other developments, mainly the result of financial pressures, point in the same direction. They include the universities' growing interest in debt financing and in developmental efforts involving close cooperation with state governments and industry. Such activities generally call for centralized decision making in the universities. More broadly, universities are displaying growing interest in strategic planning, which clearly depends on more centralized decision making.

We recommend...

1. **That universities more systematically plan their allocation of resources to favor research and equipment in areas that offer the best opportunities to achieve distinction.** Such strategic planning should involve participation by both administrators and faculty. The process may well call for hard decisions, but we believe that they must be made to optimize the use of available funds.

2. **That universities budget realistically for the costs of operating and maintaining research equipment.** These costs impose serious and pervasive problems, and failure to plan adequately for full costs when buying equipment is widespread as well. Full costs include not only operation and maintenance, but space renovation, service contracts, technical support, and the like. Maintenance is particularly troublesome. Hourly user charges are commonly assessed to cover the salaries of support personnel and the costs of maintenance, but are difficult to set optimally and are rarely adequate.

3. **That investigators and administrators at universities seek agency approval to spread the cost of expensive equipment charged directly to research-project awards over several award years.** As noted in Recommendation 3 under the Federal Government, individual research grants and contracts cannot normally accommodate costly equipment, and this problem would be eased by spreading costs over several years.

4. **That universities act to minimize delays and other problems resulting from procurement procedures associated with the acquisition of research equipment.** To be most effective, the procurement process should be adapted to the specialized nature of research equipment, as opposed to more generic products. Similarly, specialized purchasing entities or individuals would facilitate timely acquisition of equipment at optimum cost. Also beneficial would be formal programs designed to inform purchasing personnel and investigators of the needs and problems of each.

5. **That universities consider establishing inventory systems that facilitate sharing.** One such system is the basis of the research equipment assistance program (REAP) at Iowa State University. The REAP inventory includes only research equipment. REAP may not be cost effective for all universities, but most should find elements of it useful.

6. **That universities use depreciation rather than a use allowance to generate funds for replacing equipment, providing**

that they can negotiate realistic depreciation schedules and dedicate the funds recovered to equipment. Universities can use either method, but rates of depreciation are potentially higher--and so recover costs more rapidly--than the use allowance (6 2/3 percent per year) because they can be based on the useful life of the equipment. Both methods, however, add to indirect costs, and neither can be used for equipment purchased with federal funds.

7. **That universities seek better ways to facilitate the transfer of research equipment from investigators or laboratories that no longer need it to those that could use it.** Faculty at most schools have no incentive to transfer equipment, excepting the need for space, and every incentive to keep it in case it might be needed again. Some systematic mechanism for keeping faculty well informed of needs and availability of equipment would be useful.

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4

Debt Financing

INTRODUCTION

Tax-exempt debt financing has long been used by universities to fund large capital expenditures and in recent years has attracted much attention as a means of funding research equipment. The methods of debt financing employed range from long-term instruments, such as revenue bonds, to short-term leases. Regardless of the method, debt financing of research equipment must compete with the university's other needs for debt. Universities frequently use the proceeds of long-term, low-interest bonds to finance projects such as new buildings, new telephone systems, and major remodeling. When the buildings include laboratories, most of the associated fixed equipment and some movable scientific apparatus are purchased with the proceeds of the issue. In the 1950s and 1960s much scientific apparatus came with new buildings at expanding universities, but recent years have seen little net expansion.

Concern About Payment

The amount of research equipment obtained by debt financing varies widely among universities, but the central computing facility at most schools we visited was either leased or financed by borrowed funds. Universities normally use debt financing to obtain equipment for a research project only if funds are not available from other sources. The basic concern is the availability of income to cover payments on the debt.

Some universities indicated that multi-investigator and block grants are valuable in providing a stable income stream for equipment acquired through debt financing. User fees and grant or contract support, however, are the most common sources of income for payments on equipment debt or leases. Many universities are concerned that these sources are unpredictable and unreliable and that they are likely to have to subsidize debt-service costs. We learned of no central computing facility that was leased or financed by borrowed funds, for example, that had enough income to cover the total costs of the lease or debt; all required a subsidy from the school's general funds. Institutions are additionally concerned that recovery of such subsidies (i.e., the annual deficit in a specialized service center) can be very difficult to negotiate as an element of indirect cost reimbursement under OMB Circular A-21.

Because of limited opportunity to develop a reliable income stream to retire debt, some universities use no debt financing for research equipment. Some state universities are forbidden by state law to incur debt. Other universities are very active in debt financing, but generally require a fallback source of income, such as college or departmental resources, to pay the principal and interest on a debt if necessary. To obtain financing, backup commitments from departmental or college operating budgets or from a university-affiliated foundation are usually necessary.

Administrators at many universities with debt financing available appear to be very selective in its use and to restrict it to large purchases (more than $250,000) for which a repayment process can be developed. One university we visited has formal guidelines for use of a line of credit for research equipment costing more than $50,000. At others, the faculty had not been told that debt financing was a potential means of acquiring equipment. At one major university we visited, senior academic officers were unaware that a line of credit had been obtained by a senior finance officer, partially to finance research equipment.

IMPLICATIONS AND ANALYSIS IN DEBT FINANCING

An important aspect of borrowing money to buy academic research equipment is that, like assumption of debt for any purpose, it shifts the locus of responsibility and decision making. U.S. universities are decentralized in any event, and the heavy reliance on individual, competitive research grants and contracts ordinarily confers considerable authority on principal investigators. Borrowing to buy research equipment, however, imposes risk on the university as a whole and so requires a shift from decentralized to centralized planning and decision making by the school's administration. Such shifts can contribute to greater use of strategic planning by universities (see Chapter 3).

Analytical Requirements

Sound borrowing decisions demand a painstaking analysis of costs, risks, and potential impact. A thorough assessment of needs is essential. One university research foundation reported assuming a multimillion dollar debt to acquire a supercomputer without securing positive commitments from projected users. Plans to repay the debt through user charges were based on estimates and verbal assurances from potential commercial users that did not materialize. The institution was left with a very large debt and insufficient revenue from user charges to repay it.

The parameters of a needs assessment will vary. The university may wish, for example, to focus on particular types of equipment, on replacing obsolete items, or on enabling faculty to establish new programs of research. Universities also have canvassed potential external users, such as faculty at nearby institutions and government and corporate scientists, when equipment was suitable for sharing.

A problem reported repeatedly by universities was failure to plan for full costs when buying equipment. Full costs include shipping, space renovation, operation and maintenance, service contracts, technical support, insurance, utilities, and the like. As a general rule, full costs should always be included in equipment budgets and should be included, at least selectively, in calculations of how much to borrow, recognizing where appropriate the possible use of other funds to pay these costs.

The analysis also should cover projected sources of repayment, with the stress on known sources and reasonable expectations. If user charges are expected to supply revenue for repayment, for example, one cannot assume that they can be assessed at 100 percent of acquisition and interest costs without making the equipment too expensive for potential users. It may also be wise to assess as accurately as possible the allowability of interest costs under OMB Circular A-21, which requires prior agency approval to charge interest to federal grants or contracts. One university reported that its line of credit was approved for conformity with OMB Circular A-21 by five federal agencies. In the one equipment purchase thus far under this financing plan, one of the agencies declined to allow interest charges, even though the money was available in the grant through rebudgeting. The interest is being paid from private gift funds.

Prospective borrowing for equipment is best examined in terms of the university's total debt structure. This examination focuses especially on sources and amounts of revenue projected to repay all debts, repayment schedules, and overall levels of university liability. This analysis requires the university to forecast how it will meet its combined obligations and determine whether its projections are reasonable. It is important to develop at least an outline of a contingency plan for repaying equipment debt in case projected sources of repayment funds do not materialize.

Impact on Academic Programs

Evaluation of using debt for instrumentation should include the impact on the university's capacity to sustain research and instruction, focusing particularly on the future. Too much debt restricts the ability to respond to new challenges and opportunities in research and education. Some debt, judiciously designed to fit the circumstances of the university, may be very useful. In universities where faculty and administrators were satisfied with the decision to borrow, we found that debt was viewed as a supplement to other funds employed to sustain or expand existing programs and help to initiate new ones.

The Limit of Debt

We have no formula to determine how much debt a university can sustain. The appropriate level depends on many variables, including the school's philosophical approach to financial management. The National Association of College and University Business Officers says of a particular ratio of debt service to revenue, "No national standards for budget percentage dedicated to debt service may be inferred from the median values. The willingness and ability to commit revenues to debt service vary greatly among institutions."[1]

Among factors that have been identified[2] as measures of the debt capacity of a university are:

- Ratio of available assets to general liabilities (ordinarily stipulated at 2:1 minimum).
- Ratio of debt service to unrestricted current fund revenues.
- Ratio of student matriculants to completed applications.
- Ratio of opening fall full-time enrollment this year to opening fall full-time enrollment in base year.

A number of factors in addition to these ratios usually are considered in assessing the debt capacity, or creditworthiness, of universities.[3]

CHOOSING THE APPROPRIATE DEBT INSTRUMENT

A number of forms of debt financing are available to universities, and each debt instrument has terms and conditions that can be attractive in the right circumstances. Examples of the use of debt financing by universities are described in Appendix H, and representative debt instruments are summarized in Appendix I. It should be noted that the types of instruments available, the relevant tax laws and interpretations of them, and the conditions of the debt market are always subject to change.* Thus the selection of debt instruments by universities should be based on current expert advice from investment, legal, and tax counsel. The discussion of debt instruments in this chapter is intended to be illustrative, not comprehensive.

Factors to be considered in selecting a debt instrument include the amount to be borrowed and the equipment to be bought. One supercomputer, for example, may call for a different debt instrument than many devices each costing less than $100,000. The urgency of the need may be a factor--a line of credit may be arranged fairly quickly, while a bond issue is time consuming. The single most important factor in selecting a debt instrument is the correlation with use: short-term debt for short-term use, long-term debt for long-term use. Also a factor is the impact of different repayment schedules on the university's programs. In addition, different types of debt instruments have different costs, including the rate of interest, issuance costs, legal fees, and printing charges.

SHORT- TO MEDIUM-TERM DEBT INSTRUMENTS

Short- to medium-term debt instruments include leases, municipal leases, lines or letters of credit, pooled revenue bonds, tax-exempt variable rate demand bonds, and tax-exempt commercial paper. Maturities vary from 1 to 10 years. Selection criteria may include the following:

- Equipment is needed only for a specific period and may or may not have to be permanently retained by the university.
- Leasing costs can be identified with a specific piece of equipment, which can be readily identified with a grant or contract for reimbursement.

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*The material in this chapter was current as of October 1984.

- A lease can be arranged to include a maintenance and service contract.
- Short-term debt can be used temporarily until permanent funding becomes available.
- Conditions in the bond market do not favor issuance of long-term debt.
- The institution may not have the credit rating or sufficient funding needs to issue long-term debt.

The Decision to Lease or Purchase

The decision to lease or purchase usually involves a present-value analysis, in which the financing alternatives' net cash flows over time are discounted back to present-day value (see Table 6). The financing alternative with the lowest present-value cost would be considered best on a cost basis. The final decision to lease or buy depends on the prospective lessee's total financial position and equipment need. The ease and the initial low cost of entering into a lease agreement should not preclude performing cost-benefit analyses of other debt alternatives. Over the long term, high-priced, long-term equipment will most likely have a higher net effective cost under a lease arrangement than under a long-term debt instrument. For short-term, low-priced equipment, the university might consider a line of credit as an alternative to leasing.

General Uses of Leasing

Ordinary leasing takes two basic forms:

- Operating lease: an institution acquires the use of equipment for a fraction of its useful life. Title is retained by the lessor, and the lease contains no option to purchase the equipment. The lessor may provide services in connection with maintenance and insurance of property.
- Capital lease: a capital lease must meet one of the following criteria:
    - Title is transferred to lessee at the end of the lease.
    - Lease contains a bargain purchase option.
    - Lease term is at least 75 percent of the leased property's estimated economic life.
    - Present value of the minimum lease payments is equal to 90 percent or more of the leased property's fair market value, less related investment tax credit retained by the lessor.

TABLE 6 Present Value Analysis

Yr.	Outflow($)	Inflow($)	Net($)	PV Factor*	Net Present Value($)
Option A					
0	1,000,000	0	(1,000,000)	1.000	(1,000,000)
1	100,000	500,000	400,000	0.909	363,600
2	100,000	500,000	400,000	0.826	330,400
3	100,000	500,000	400,000	0.751	300,400
4	100,000	500,000	400,000	0.683	273,200
5	100,000	500,000	400,000	0.621	248,400
Net present value					516,000
Option B					
0	0	0	0	1.000	0
1	400,000	500,000	100,000	0.909	90,900
2	400,000	500,000	100,000	0.826	82,600
3	400,000	500,000	100,000	0.751	75,100
4	400,000	500,000	100,000	0.683	68,300
5	400,000	500,000	100,000	0.621	62,100
Net present value					379,000

DECISION: Option A, purchasing equipment with available cash.

Option A states that the acquisition of new laboratory equipment will save the department $500,000 per year in contracting the services from a private lab. Costs of about $100,000 per year are directly attributable to the new equipment maintenance which will reduce the potential annual savings to $400,000. The cost of the equipment and its installation is $1.0 million. At the end of five years, the equipment has zero salvage value. Option B states that the leasing of new laboratory equipment will save the department the same $500,000 as in Option A. The cost of lease will be $300,000 per year for five years with an additional $100,000 per year for maintenance. The department has no purchase option at the end of the lease.

*PV factor assuming a 10 percent discount rate.

SOURCE: Coopers & Lybrand.

The benefits commonly attributed to leasing are primarily available in a tax-oriented lease in which the lessor retains and claims the tax benefit of ownership. This type of lease is called a true lease for tax purposes. Nearly all operating leases are considered true leases, but only some capital leases qualify as true leases.

Not-for-profit organizations do not accrue tax benefits from leasing capital equipment, benefits that are available to profit-making organizations. With state universities, IRS regulations prevent the lessor from benefiting from the investment tax credit because the end property user is a government entity. Leases can be structured, however, to pass on the tax benefits of ownership to the lessor. These methods include a sale-leaseback and third-party lessor, which may be an affiliated foundation (see Chapter 5). Such methods require careful review and professional counsel to ensure that the transaction is structured to meet IRS regulations and other federal requirements.

State universities have structured leases as a sale-leaseback transaction in which the equipment is sold by the university to purchaser/lessor and then leased back by the university. These arrangements are considered operating leases, allowing the purchaser/lessor to receive the tax benefits. In most cases, however, the sale-leaseback is not the best method relative to other forms of tax-exempt financing available to state universities (e.g., bank line of credit).

Private universities, for major projects that include both buildings and equipment, can combine debt financing with leases. This arrangement allows the university to match the economic life of the asset with a comparable financing period. However, the institution should consider tax-exempt financing (e.g., a line of credit or industrial revenue bond) for major funding needs or for aggregate university funding, because tax-exempt financing could be a cheaper form of debt than leasing equipment on an individual basis.

Foundations established as separate, incorporated entities can provide additional financing flexibility to state universities. Such foundations can offer a number of benefits by incurring debt and arranging leasing on behalf of a university. An example is the Georgia Tech Research Corporation mentioned in Chapter 3. A state institution and the foundation will have an arm's-length relationship that can provide needed financing while complying with various state regulations.

Municipal Leases

Municipal leases require the lessee to be a state, city, or government entity, and so do not apply to private universities.

For tax and legal purposes, the municipal lease is considered a conditional sales contract. Municipal leases usually include the following provisions:

- The university receives title to the equipment for a nominal fee at the end of the lease term.
- No down payment is required from the university.
- The university makes clearly defined payments of principal and interest.
- The lessor receives none of the tax benefits of ownership, but can treat the interest portion of the lease payments as tax-exempt income.
- The lease term is generally on a fiscal year-to-year basis with renewable options; the university's liability is limited to the actual lease term (excluding renewable options), so it can cancel the lease at the end of each year.

Through a municipal lease, a state university can enter into a lease-purchase agreement and still meet state constitutional or statutory constraints on multiyear debt. The cost of the lease usually ranges from 70 to 90 percent of the prime interest rate; the high cost reflects the lessor's risk that the lease can be cancelled on a year-to-year basis. Interest, however, is the only expense associated with the lease. Also, the ability to cancel on a year-to-year basis provides some insurance against technological obsolescence.

Municipal leases generally are used to acquire equipment costing in the range of $100,000 to $1 million. They are also useful for acquiring lower priced equipment: they can be arranged quickly and normally are used to acquire small pieces of equipment that depreciate quickly and have questionable salvage value.

Mechanics

In arranging a municipal lease, the university selects the equipment and deals directly with the vendor on the sale terms and price. When the terms are settled, the university negotiates the lease with a third-party lessor. Municipal leases usually include a fiscal funding clause to protect the lessee from any claims the lessor may have against cancellation of the lease. The clause makes the lease conditional on full appropriation of funds to pay the lease in the next fiscal year. If the lease includes such a clause, the lessor may require a nonsubstitution clause to protect against the lessee's cancelling the initial lease on the basis of nonappropriations and then leasing similar equipment from another lessor.

Third-Party Lessors

An affiliated nonprofit organization or foundation could enter into a municipal lease arrangement for a state university. The foundation would act as a third-party lessor and could provide:

- Additional financial security to back the leasing arrangement.
- Review of department heads' and principal investigators' municipal-lease requests to ensure that revenue sources are available to cover lease commitments.
- Management of the leased equipment.
- Support for collecting and paying lease payments.

Additionally, the foundation would not be subject to fiscal appropriations and would be able to plan for the funding of long-term lease contracts.

Line of Credit

A university that anticipates a near-future need for borrowed funds but does not know its specific requirements can negotiate with a bank for a line of credit. The line of credit represents an assurance by the bank that funds will be made available to the university as needed, based on the terms and conditions of the initial agreement and barring any major changes in the financial position of the university. Once a line of credit is negotiated, the university can request funds from the bank. The bank reviews the request(s) and extends the loans up to the stated limit of the line of credit. Lines of credit usually are extended for one to five years and for ceilings of $2 million to $15 million on outstanding loans.

A line of credit gives the university a standby source of funds that can be obtained without having to renegotiate terms and conditions each time a loan is needed. By paying a fee on the unused portion of the funds, the university can arrange a letter of credit or a standby loan guarantee from the bank to ensure the funds' availability.

Mechanics

A university with an established credit rating can most likely negotiate with a number of banks before arranging a line of credit with one of them. Depending on its financial strength, the university may be able to arrange more than one line of credit. The general terms of a line of credit specify:

- Interest rate will average 60 to 75 percent of the prime interest rate because the line of credit is considered a tax-exempt debt.
- Loan ceiling represents the total amount of credit that the bank will extend to the university under the line of credit.
- Put and call provisions state the period in which the bank can request repayment in full of all outstanding loans and the period in which the university can prepay its loan.
- Fee represents the bank's compensation for extending the line of credit; it can be expressed as a stated amount or as a percentage of the unused line of credit.
- Conditions define specific terms of the line of credit, e.g., the bank may ask the university to maintain compensating bank balances, depending on the underlying credit of the university and the bank's loan pricing structure.
- Security defines the collateral the bank requires to support the loan (e.g., the university's pledge of unrestricted endowment funds or a lien on the purchased equipment).

Procedures for Use

Once a bank line of credit is obtained, the university should establish procedures for using it. The line of credit could be drawn upon, for example, to meet loan requests from department heads and principal investigators. Each request would have to be documented to justify the loan and demonstrate a source of revenue to repay it. Internal administrative controls would have to be established to review and process requests and ensure that the use of the line of credit conforms to budgetary and research priorities. If numerous small loans were made, additional administrative control would be required to monitor loan limits and debt service.

Pooled Revenue Bond

A pooled revenue bond is issued under a designated government authority to meet the aggregate funding requirements of a group of state or private institutions. Bond pools are of two types: a blind pool does not identify the participating universities or the projects to be funded; a composite pool identifies both.

To ensure the marketability of the bond issue, the authority will most likely purchase an insurance policy that guarantees repayment in the event of default by any of the participating universities. The authority may require a participating university that does not have an established credit rating to obtain a letter of credit to guarantee its loan or to pledge cash and securities as collateral. Financially strong universities that can issue their own debt may not gain cost advantages from participating in the pool. The participation of universities with established credit ratings, however, is important to ensure that the pooled revenue bond gets a favorable rating and can be marketed to investors.

The pooled revenue bond meets the minimum requirements ($5 million to $10 million) for a marketable, cost-effective issue, and the costs of issuance are shared by the participating institutions. It works well when the participants need similar types of equipment: investors are looking for some element of commonality--such as the useful life of equipment--so that they can better assess their risks. The mechanism permits a university to finance equipment purchases that would not warrant issuance of a revenue bond on its own.

Mechanics

After the bonds are issued, the authority enters into a loan agreement with each participating institution. The agreement specifies the term and amount of the loan, the repayment schedule, and the interest rate. The periods of the participating institutions' loans generally range from three to ten years, but no loan can extend past the maturity date of the bond issue. IRS regulations give the authority three years to disburse the proceeds of the bond. Within that period, the authority may invest the proceeds at a higher rate than the tax-exempt rate of the bonds to reduce the borrowing costs to the participants.

Tax-Exempt Variable Rate Demand Bond

Tax-exempt variable rate demand bonds (VRDBs) carry a floating interest rate set periodically in one of three ways:

- Percentage of prime interest rate.
- Percentage of 90-day U.S. Treasury Bill rate or bond equivalent basis.
- Indexed to tax-exempt notes.

The VRDB, nominally issued with a 25 to 30 year maturity, gives the university access to long-term debt at short-term rates. When issuing long-term debt is not feasible or is relatively expensive, VRDBs permit the university to begin construction of buildings or procure equipment without funding delays; they permit the issuance of permanent debt to be postponed until conditions in the long-term bond market improve. The short-term feature of the VRDB can offer quite favorable interest rates, which may range three or more percentage points below fixed long-term bond rates. VRDBs entail risks if the university plans eventually to convert them to long-term debt. One such risk is the uncertainty in the regulatory environment, which may restrict the university's ability to issue long-term debt. One of the many varieties of variable rate demand bonds is the adjustable rate option bond described in Example G, Appendix H.

Mechanics

VRDBs are issued for the university by a designated state or local authority. The bonds are sold to short-term investors, normally tax-exempt money market funds that can only hold securities with maturities of 90 days or less. The terms generally give the investor the option of returning the bonds to the issuer after giving a seven-day notice and give the issuer the option of recalling the bonds from the investors upon a 30-day notice. (The adjustable rate option bond in the example allows only annual returns of the bonds for payment.) Because the investor can return the bonds, the university must demonstrate its ability to pay for them. If the bonds can be immediately resold, the university can readily repay the investor. If new investors cannot be found, however, the university needs some way to raise the necessary capital. The most common way is a bank letter of credit.

Through a letter of credit agreement, the bank lends the university the necessary funds at a specified rate of interest and with a set repayment schedule. Borrowing under the terms of the letter of credit can be costly, in that the interest rate is higher than the university is paying on the VRDBs. Most universities will have to use it, however, because the institution may have insufficient cash reserves to ensure repayment of the VRDBs. With the letter of credit the bank may provide other services, including placement of the initial bond offering and assistance in locating new investors if initial investors return the VRDBs. (In many cases, investment bankers provide the marketing and remarketing service.) The university and its bank negotiate the terms of the letter of credit, which generally costs from 1 to 1.5 percent of the amount of the issue and has a five-year term with cancellation and renewal clauses.

Tax-Exempt Commercial Paper

Tax-exempt commercial paper (TECP) consists of a program or series of short-term obligations with maturities of 270 days or less, issued by a designated authority for a pool of universities. TECP gives universities the flexibility and liquidity of short-term borrowing at the lower interest rates offered on tax-exempt securities. Issuance costs are shared by the participants. Additionally, the TECP is designed to be rolled over at maturity without delays and added issuance cost, so the university is not locked into long-term debt and can repay the loan at any time without penalty.

Mechanics

The designated authority would issue the tax-exempt commercial paper and provide the funds to participating institutions that request loans to finance the construction or renovation of buildings and the acquisition of equipment. The issued amount of the TECP would reflect the aggregate amount of the participating institutions' loan requests over the period of the program, say, two or three years. The relatively high cost of setting up a tax-exempt commercial paper program makes it necessary to aggregate fairly large pools of money. The minimum for the pool commonly is $50 million.

The TECP would be a limited obligation of the authority and would represent no obligation of the authorizing state or county. The financial backing for the issue is the revenues and pledged funds of the participating universities. Before a loan is made, the authority must approve the creditworthiness of the participating institutions. An institution that does not have an established credit rating could obtain a letter of credit or pledge assets as collateral. The authority would make a long-term loan to the institution for a period not greater than the expected life of the debt program, which could be as long as 10 years.

The university would repay its loan in equal monthly installments that would reflect repayment of principal and the costs of interest, administration, and issuance. The interest on the loan would be determined monthly and reflect the average interest rates of TECPs sold during the month. Repayment of the TECP is based solely on participating institutions' loan payments to the authority.

LONG-TERM DEBT INSTRUMENTS

Long-term financing commits a university to 10 to 30 years of debt. Tax-exempt revenue bonds and general obligation bonds are the major forms of long-term financing. Certificates of participation, industrial development bonds, and "on behalf of..." debt instruments are specific forms of revenue bonds.

Types of Tax-Exempt Bonds

For state, local, and other municipal government entities and authorities, municipal bonds are a major means of financing the construction and maintenance of public facilities. Municipal bonds are cost effective because the interest paid to the bond holders is exempt from federal income tax and sometimes from state or local income tax. The tax-exempt status permits issuers of municipal bonds to pay lower interest rates than are paid on corporate bonds.

Municipal bonds are differentiated by the type of funds that secure payment. The bonds are of two general types:

- General obligation bonds are secured by the taxing power of the state or local government. All sources of the specified government unit's revenues will be used to pay off the debt, unless specifically excluded. The bonds are backed by the "full faith and credit" of the state or local government.
- Revenue bonds are issued to finance a specific revenue-generating project. They are secured by the project's revenue and are not backed by the "full faith and credit" of a state or local government.

Long-term debt financing for universities generally involves revenue bonds or industrial development bonds. The industrial development bond is issued by a state, local, or other designated government entity to finance the construction or purchase of plant facilities or equipment to be leased and used by a private entity. The bond is backed by the credit of the private entity and not by the issuing government entity.

Revenue bonds do not burden the credit capacity of the municipality nor require a referendum, as do most general obligation bonds. The state or local government issues the revenue bonds or empowers an authority, commission, special district, or other unit to issue the bonds and construct and operate or lease the specified building/equipment.

Revenue and industrial development bonds can be used by both state and private institutions. The tax-exempt bond can be issued as long as it fulfills a "public purpose" under state law in accordance with Internal Revenue Code Section 103. State universities enjoy tax-exempt status because they are considered subdivisions of the state. A private university, however, must use a tax-exempt conduit such as a county, industrial development authority, educational facilities authority, or similar agency. Revenue bonds issued by both state and private universities are backed by the creditworthiness of the institution. If it does not have sufficient collateral to attract investors, the issue would most likely have to be underwritten by an insurance company to ensure its marketability. Other forms of credit enhancement are available. The university might obtain a letter of credit, for example, or, where feasible, set aside a portion of endowments as collateral. Such credit enhancements have the effect of lowering the interest rate that must be paid to attract investors.

Mechanics

The tax-exempt bond is a legal promise by the backer—municipality, political subdivision, designated public authority, state university, or private university--to pay the investor a specified amount of money on a specified date and to pay interest at the stated period and rate. A bond issuance basically involves four main parties or groups of individuals:

- The institution—in this case a state or private university, responsible for paying principal and interest from its own revenues.
- The issuer—a governmental entity or designated authority that borrows money through sale of tax-exempt bonds.
- The dealers--securities firms or commercial banks that underwrite, trade, and sell securities.
- The investors--tax-exempt bond funds, banks, casualty insurers, and individuals.

The minimum feasible amount of a bond issue is normally $3 million because of the sizable costs of bringing the issue to market. These costs would include legal, accounting, and brokerage fees as well as incidental costs such as printing. Individual bonds have a minimum face value of $5,000, but on average are issued in $25,000 denominations.

Legal and tax counsel are essential to ensure that all reporting, tax, and disclosure requirements are met. Municipal security issues do not have to follow the reporting requirements of the Securities and Exchange Commission (SEC), but the Municipal Securities Rulemaking Board, an independent, self-regulatory organization of dealers, banks, and brokers, has established guidelines for the municipal securities industry. A potential issue would be governed by the antifraud provisions of the Securities Acts and SEC Rule 10b-5. Additionally, a tax-exempt bond must adhere to Internal Revenue Code Section 103, which defines the types of facilities that can be financed with tax-exempt bonds.

Certificates of Participation

Certificates of participation (CPs) are a relatively new debt instrument that resulted from the need of public institutions to lease high-priced facilities. This form of financing provides access to the equivalent of long-term debt, but does not constitute direct indebtedness. The legal structure of CPs is basically the same as for a lease-purchase agreement. CPs, however, allow a university to lease costly facilities and equipment with several investors acting as the lessor. CPs represent a share in a lease--the certificate holder has an interest in the lease proportional to the percentage of the investment. The underwriting for CPs is complex and lengthy; the efforts and cost are comparable to those of issuing a revenue bond. CP investors will require some form of security from the university to ensure that funds are available to meet lease payments. In some cases, the university may have to purchase a letter of credit or establish a debt reserve fund to cover one year's debt service. The cost of placement requires that the CPs be issued for at least $1 million.

"On Behalf of..." Financing

"On behalf of ..." financing is arranged by a third-party guarantor for a state or private institution. The financing could take the form of either a revenue bond or a lease. Generally, "on behalf of ..." financing is used for special equipment. A tax-exempt foundation (third-party guarantor) issues a revenue bond on behalf of the university to purchase the equipment. When the equipment is acquired, the foundation leases it to the university. The university makes lease payments to the foundation and receives title to the property at the end of the lease. Although the foundation is the guarantor of the "on behalf of ..." issue, the bond or lease represents an indirect obligation of the institution. "On behalf of ..." investors look to the university's revenue-generating capability and creditworthiness to evaluate the riskiness of the issue.

An advantage of "on behalf of ..." financing is that the debt does not appear on the university's balance sheet. The financial impact on the university is reflected as a contingent liability for future lease payments. The leasing arrangement between the foundation and the university is on a year-to-year basis with annual renewal options. A state university would use "on behalf of ..." financing only when revenue bonds could not be issued. Some state governments have legislative authority over the state university's ability to issue revenue bonds and can restrict the purpose of the bond and the use of the funds. "On behalf of ..." financing would be easier to issue than revenue bonds in these states, but the cost of issuance is higher.

INNOVATIVE TECHNIQUES

A number of innovative financing techniques have been used for state and private universities. One of these is to structure the bond issue so that the institution's alumni may be investors, not just contributors. The bonds are issued and purchased by alumni. The proceeds are placed in an irrevocable charitable remainder trust from which interest payments are made to the bond holders. The alumni can claim the principal of the bond as a charitable donation for tax purposes and also can treat the interest as tax-exempt income. When the bonds mature, the trust is retired and the principal goes to the university. The financial advantage to the university is a substantial reduction in debt service. The major disadvantage of this type of financing is that the institution does not have use of the funds until the bonds are retired; for this reason, the bonds should be issued with short-term maturity.

Grantor Trust

A mechanism proposed recently by an investment banking firm involves a lease pool large enough to spread financing costs over many leases with consequent economies of scale. The goal is to finance acquisition of equipment from research awards over three to seven years while avoiding the problems associated with pooling funds from different award periods and possibly from different awards.

The proposal envisions a grantor trust created to acquire tax-exempt lease obligations of participating universities. (The specific proposal involves a nonprofit corporation of some 55 universities—the Universities Space Research Association--formed originally for other purposes.) The trust would offer investors certificates of participation that provide tax-exempt income and return of capital in three to seven years. An initial offering on the order of $20 million is contemplated. Additionally, corporate guarantees would be sought to cover up to 25 percent of the pool in case of defaults or failure to exercise annual lease-renewal options. Advances made by corporations under these guarantees would be structured as tax-deductible contributions. The guarantees would be designed primarily to make the certificates of participation more attractive to investors, and the grantor trust would not anticipate involving them.

RECOMMENDATIONS

Universities traditionally have used tax-exempt debt financing to spread payments for costly facilities over periods of years and lately have been using the method to some extent to buy research equipment. A number of financing methods can be adapted to the special characteristics of equipment, such as its relatively short technologically useful life. A noteworthy aspect of debt financing is its imposition of risk on the university as a whole, which requires a shift from decentralized toward centralized authority.

We recommend...

1. **That universities explore greater use of debt financing as a means of acquiring research equipment, but with careful regard for the long-term consequences.** Universities vary widely in their use of debt financing, but a universal concern is the need for a reliable stream of income to make the debt payments. It should also be recognized that the necessary commitment of institutional resources, regardless of the purpose of the debt financing, erodes the university's control of its future, in part by reducing the flexibility to pursue promising new opportunities as they arise. Debt financing also increases the overall cost of research equipment to both universities and sponsors of research.
2. **That universities that have not done so develop expertise on leasing and debt financing of equipment.** This expertise should include the ability to determine and communicate the true costs of debt financing and should be readily accessible to research administrators and principal investigators. The increasing complexity of tax-exempt debt financing, the many participants, the necessary legal opinions, and the various political and/or corporate entities associated with debt financing make it essential that universities fully understand the marketplace.

REFERENCES

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2. Peat, Marwick, Mitchell & Co., *Ratio Analysis in Higher Education* (Washington, D.C., 1982).
3. Hyman C. Grossman, "Higher Education Credit Rating Criteria" (Presentation to a Symposium on Higher Education Capital Finance, Morgan Guaranty Trust Company, New York, November 2, 1984).

5

Private Support of Academic Research Equipment

INTRODUCTION

Higher education in this country has long enjoyed significant support from private sources, including individuals, foundations, and business and industry. Universities increasingly have been seeking such support, and it has risen steadily in recent years. Private assistance to academe takes various forms, and in some measure is helping to address the need for research equipment.

An increase in private support for academic research equipment was one of the aims of the federal Economic Recovery Tax Act (ERTA) of 1981 (PL 97-34). The act resulted from concern over the nation's industrial strength and was designed in part to spur research and development, both academic and industrial. It permits special charitable deductions for scientific equipment contributed by its manufacturers to colleges and universities. It also provides tax credits for industrial spending on R&D conducted both in-house and by other performers, including universities. The act took effect in August 1981, and, unless extended, certain provisions will expire December 31, 1985.

Extent of Private Support

Data on trends in funding of academic research equipment do not exist. Data are available, however, from the NSF National Survey of Academic Research Instruments on major instrumentation systems in use in 1982-1983. The data show that industry funded 4 percent of the aggregate acquisition cost of such systems and that individuals and nonprofit organizations funded 5 percent (Table 3, Chapter 2). The NSF data show also that about 2 percent of the instrumentation systems in use in 1982-1983 were donated, as opposed to being purchased by the universities (Table 7).

TABLE 7 Means of Acquisition of Academic Research Instrument Systems in Use in 1982-1983, by Field (Number and Percent of In-Use Systems)

	Total	Purchased New	Locally Built	Purchased Used	Donated		Govt. Surplus	Other
					New	Used		
Total, Selected Fields	36,351	32,409	942	1,342	410	317	409	522
	100%	89%	3%	4%	1%	1%	1%	1%
Agricultural Sciences	1,650	1,575	17	39	4	2	5	9
	100%	95%	1%	2%	-	-	-	1%
Biological Sciences, Total	15,043	14,138	71	475	22	36	43	259
	100%	94%	-	3%	-	-	-	2%
Graduate Schools	6,358	5,959	40	234	4	13	10	98
	100%	94%	1%	4%	-	-	-	2%
Medical Schools	8,685	8,179	31	241	17	24	32	162
	100%	94%	-	3%	-	-	-	2%
Environmental Sciences	2,122	1,756	98	103	26	31	88	19
	100%	83%	5%	5%	1%	1%	4%	1%
Physical Sciences	8,770	7,502	366	428	20	98	196	161
	100%	86%	4%	5%	-	1%	2%	2%
Engineering	6,786	5,613	379	209	309	126	78	72
	100%	83%	6%	3%	5%	2%	1%	1%
Computer Science	876	766	0	56	30	23	0	0
	100%	87%	-	6%	3%	3%	-	-
Materials Science	650	619	7	22	0	0	0	2
	100%	95%	1%	3%	-	-	-	-
Interdisciplinary, not elsewhere classified	454	440	4	10	0	0	0	0
	100%	97%	1%	2%	-	-	-	-

NOTE: Sum of percents may not equal 100 percent because of rounding.

SOURCE: National Science Foundation, National Survey of Academic Research Instruments and Instrumentation Needs.

Trends in funding of R&D presumably apply grossly to the funding of the associated equipment. For example, in 1983 industry funded about 5 percent of academic R&D. Industrial funding of academic R&D, in constant dollars, grew at an average annual rate of 6.7 percent during 1967-1983 (Appendix A). The comparable growth rate for federal funding was 1.6 percent. Federal funding of academic R&D in 1983, however, totaled $4.96 billion (current dollars), or 64 percent of total funding and more than 13 times the industrial contribution. A drop of 1 percent in the federal support of university research would require a 20 percent increase in industry support to make up for it.[1]

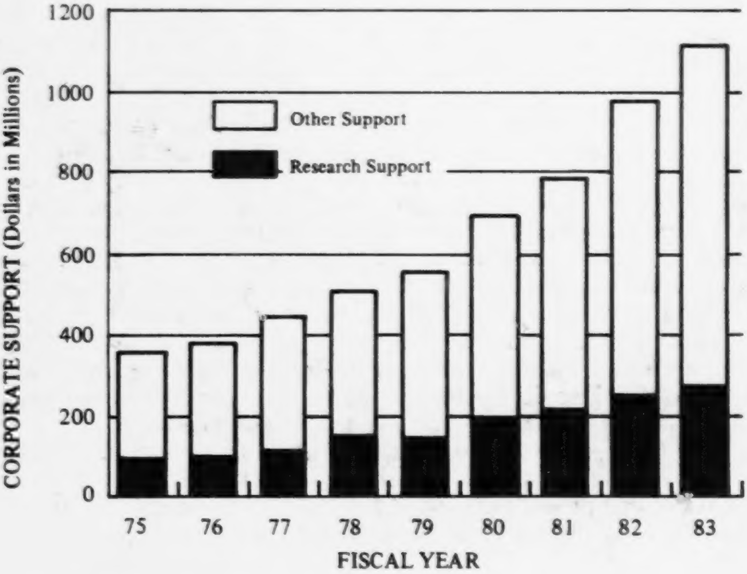
In addition to the foregoing NSF data is information on corporate support of academe compiled by the Council for Financial Aid to Education (CFAE). The two sets of data partly overlap and so cannot be combined to give totals. In any event, the CFAE data show that voluntary private support of higher education, from all sources, more than tripled during 1966-1983, to $5.15 billion. Corporate support has been rising faster than other private funding and in 1983 comprised 21.4 percent of the total. Corporate support also is more than twice as likely to be earmarked for research as are contributions from other private sources; corporate giving so earmarked in 1983 was 25 percent of the total, or $274 million (Figure 9). The most dramatic change in corporate giving between 1980 and 1982, CFAE's most recent survey years, was in departmental and research grants, which almost doubled.[2] Gifts of equipment accounted for much of the gain. CFAE believes that ERTA contributed significantly to corporate giving of equipment.

MECHANISMS OF CORPORATE SUPPORT

Companies support acquisition of academic research equipment by a variety of means in addition to donations of equipment itself. These mechanisms include cash gifts, contract research, discounts on equipment, industrial affiliate programs, research centers and consortia, and informal loans and sharing.

Donations of equipment have been particularly common in computing, microelectronics, and engineering, but less so in other areas. Equipment offered for donation, however, may not be state of the art, particularly in industries where the technology is advancing rapidly. Also common are offers of instrumentation that does not meet the research needs of the proposed recipient. Further, donations of equipment generally do not provide for the costs of renovating space and installing, operating, and maintaining the equipment. These costs have prevented some universities from accepting donations. In Chapter 3 we cited the university

FIGURE 9
National Estimates of Corporate Voluntary
Support of Colleges and Universities
Fiscal Years 1975-1983



SOURCE: Council for Financial Aid to Education.

visited by the study team that declined a gift of computer-aided design equipment because it could not afford the $170,000 per year required to operate it.

Cash gifts support a variety of research and instructional needs, including research equipment. Some companies have set up organizations to plan corporate philanthropy, including matching of employees' contributions to colleges and universities. Companies sometimes help to support the research of a particular investigator or program. Unrestricted cash gifts often are applied wholly or partly to the costs of acquiring and using instrumentation and sometimes are used to meet federal matching requirements for buying equipment.

Companies generally fund contract research at universities on a project-by-project basis, much as federal agencies support contract research. Academic investigators and administrators, however, report significant differences in the handling of industrial and federal research contracts. Negotiations with industry are not hampered by the problems associated with federal regulations identified in Chapter 1. Corporate negotiators, moreover, recognize that state-of-the-art equipment and the costs of operating and maintaining it are part of the price of effective research. Contracts with industry, therefore, are more likely to cover all of these costs than are federal contracts.

Companies frequently use discounts and flexible payment schedules, often free of interest, to help universities obtain research equipment. These mechanisms in the aggregate can provide substantial benefits to universities. One company visited by the study team used a two-for-one discount on purchase of new equipment to generate goodwill and to institute a series of informal exchanges between its scientists and investigators at the recipient school.

Industrial Affiliates

Industrial affiliate programs (also called industrial liaison programs) provide substantial support for departments and programs at a number of universities. The companies involved pay annual membership fees that vary with the arrangement, but often are in the range of $30,000 to $50,000 per company. The university in turn generally provides seminars conducted by faculty, preprints of publications, copies of theses and dissertations, and informal contact with faculty and students. Some programs also provide a limited amount of consulting by faculty at no charge. These industrial affiliate arrangements can provide considerable discretionary funding, which could be used to purchase research equipment.

An elaboration of the industrial affiliate concept is the research center or consortium. These arrangements may be organized to pursue mission-oriented research. Centers for research on very large-scale integration of electronics, for example, are being established at MIT and Stanford. The corporate members of the Stanford center initially contributed $750,000 each. Of the $20 million thus raised, more than $4 million was used to acquire state-of-the-art instrumentation. Annual corporate dues are $100,000 per company and are expected to comprise one-sixth of the center's sponsored research budget, with the remainder to come from federal agencies. The privileges of membership include limited rights to certain aspects of the technology developed in the center's research programs.

A somewhat different approach is the Houston Area Research Center (HARC). It was formed in 1982 by four universities—Rice, Texas A&M, Houston, and Texas-Austin—to conduct research that none of them could handle easily alone. HARC received private funding initially, and now has begun to receive federal contract funding. Projects under way in 1984 included raising funds for a supercomputer for the four schools and surrounding industry, development of geological testing techniques and large-scale geological surveys and studies, and support for activities in high-energy physics.

Another vehicle of corporate support is a nonprofit corporation, supported by contributions from companies, which funds contract research at universities. The arm's-length sponsored research agreements negotiated can provide significant funding for research equipment. One example of such an arrangement is the Center for Biotechnology Research, in San Francisco, California. It is supported by six companies and administered by a three-member board of trustees.

Academic investigators occasionally benefit from informal loans or sharing of company-owned equipment. Most often such arrangements result from personal contacts between scientists.

Freedom of Inquiry

A critical issue in academic-corporate relationships is preservation of the academic freedom that contributes so much to the strength of research in our universities. The proprietary interests of a corporate sponsor of research, for example, are inherently in conflict with the academic practice of open and rapid dissemination of research results. Means of managing academic-industrial relationships have been examined increasingly in recent years as such arrangements have proliferated.[3,4] The general issue is beyond the scope of this report, but certainly must be considered in arrangements to secure corporate funding of academic research equipment.

OTHER PRIVATE SUPPORT

The NSF data cited earlier indicate that private individuals, not-for-profit organizations, and foundations fund academic research equipment at a level comparable to corporate support. Philanthropic programs generally support instrumentation through research grants and general program support. Universities have raised matching funds for research equipment from individual private donors and philanthropic organizations. The added leverage of matching funds, plus the appeal of current sophisticated technology, help scientific research to compete with efforts to raise funds for other activities, such as athletic programs and hospitals. Universities report that fund drives for specific items of research equipment have proved effective.

Individuals also may help to fund academic research equipment by investing in bonds issued to raise money for universities (see Chapter 4) or in research and development limited partnerships (see below).

TAX INCENTIVES

Corporate and other private entities traditionally have been allowed tax deductions for donations of cash and property to colleges and universities. ERTA, however, in response to the need for research equipment in academe, attached permanent special tax benefits to donations of such equipment by its manufacturers. Also, in accord with its basic goal of spurring technology, ERTA created additional tax credits for industrial investment in research and development, including academic R&D. (Unless extended, the R&D tax credit will expire December 31, 1985.) Further, most of the states in recent years have adopted tax incentives identical or similar to the federal provisions relating to contributions of scientific equipment. In addition to these federal and state provisions, tax benefits are available to research and development limited partnerships, which might provide some support for academic research programs.

Contributions of Scientific Equipment

A company that donates equipment to a charitable (tax-exempt) organization generally is allowed a tax deduction equal to the cost of the equipment to the company (production cost). ERTA increased the deduction to production cost plus half of the difference between cost and fair market value (normal selling price) for equipment donated to institutions of higher education, subject to certain provisos, among them:

- The donor must be the manufacturer of the equipment. The cost of parts from outside suppliers may not exceed 50 percent of the donor's cost in the equipment.
- The equipment must have been manufactured no more than two years before donation, and the university must be the original user.
- At least 80 percent of the use of the equipment must be for research or research training in the physical or biological sciences. Direct education of students in these fields is excluded, and the social and behavioral sciences are excluded altogether.
- The equipment must be used in the United States, and the university may not transfer it to others for money, other property, or services. The university must verify in writing that it will meet all use and disposition requirements.
- The deduction is limited to twice the production cost of the equipment. If the cost of the equipment to the manufacturer is $100, for example, the tax deduction is limited to $200, regardless of the normal selling price of the equipment.

In addition to increasing the deduction for such contributions, ERTA raised the limit for corporate charitable deductions from 5 percent to 10 percent of taxable income. Although many corporate donors do not reach even the 5 percent limit, some do, and the higher limit on deductions clearly could affect the level of corporate contributions of equipment to academe.

The incentive provided by ERTA for donating qualified equipment to colleges and universities can be assessed on two bases: the direct cost of donation (production cost less tax benefit) and the total cost of donation (production cost, plus net income foregone by donating rather than selling, less tax benefit).[5] These relationships are shown in Table 8, using a production cost of $100 and selling prices of $100, $300, and $400. Note that the tax deduction under ERTA plateaus at a selling price of $200 (twice the production cost). At that point, ERTA confers its maximum reduction, about 28 percent, in total cost of donation. Net income foregone, however, continues to rise, so that, at a selling price of $400, ERTA reduces the total cost of donation by about 21 percent. Even so, it would appear that ERTA offers a significant incentive to donate qualified equipment to academe. If the data of Table 8 are raised to more realistic levels--say, a production cost of $100,000 and a selling price of $300,000—the direct

TABLE 8 Effect of ERTA on Cost of Donating Equipment (in Dollars)

	ERTA/non-ERTA		
Production cost	100/100	100/100	100/100
Selling price	100/100	300/300	400/400
Tax deduction	100/100	200/100	200/100
Tax benefit (at 46 percent tax rate)	46/46	92/46	92/46
Direct cost of donating (cost less benefit)	54/54	8/54	8/54
Net income foregone (price less cost less tax on gross profit)	0/0	108/108	162/162
Total cost of donating (cost plus net income foregone)	54/54	116/162	170/216

SOURCE: Eileen L. Collins, *An Early Assessment of Three R&D Tax Incentives Provided by the Economic Recovery Tax Act of 1981* (Washington, D.C.: National Science Foundation, April 1983).

cost of donating becomes $8,000 under ERTA and $54,000 without ERTA. Similarly, the total cost of donating becomes $116,000 under ERTA and $162,000 without ERTA.

Bargain Sales

A company that wishes to provide qualified research equipment to a university but is unwilling to donate it outright may still obtain tax benefits under ERTA by means of a bargain sale. A bargain sale is a sale for less than fair market value, often entailing a larger than normal discount. The university gets the equipment at a good price; the donor receives a tax deduction for a charitable contribution, but also must recognize gain on the transaction to the extent that the sales price exceeds the cost basis apportioned to the sale. The calculation is illustrated in Table 9. The university pays $750 for equipment that lists at $1,500. The company receives a $250 after-tax profit under the bargain sale provisions of ERTA, or 85 percent more than the $135 it would have received without ERTA. It should be noted also that the charitable deduction under ERTA is limited to twice the cost basis of the equipment.

Company Considerations

Companies' decisions on how best to provide research equipment to academe on a charitable basis depend on both tax and nontax considerations. The two are necessarily intertwined, but nontax benefits are the primary impetus for giving.

Makers of scientific equipment depend very much on academe as a market for their products and as a source of the technically trained manpower and research results essential to their businesses. They provide equipment on a charitable basis, therefore, to sustain the quality of teaching and research, to familiarize prospective users and employees with their products, to obtain feedback on the performance of their equipment and on needs for new products, and to maintain relations with faculty.

Although tax benefits are not the primary motivator, they do appear to affect the contribution of equipment to universities. A company may prefer, for example, to sell costly, high-profit equipment to a university at a substantial discount, rather than donating it, so as to ease the economic penalty of the contribution.[6] This approach has been used both before and after ERTA, but ERTA clearly could affect the decision to sell or donate. Tax benefits also appear to affect the size of contributions, once the decision to contribute has been made.

TABLE 9 Calculation of Gain and Charitable Deduction in Bargain Sale

List price = $1500
Cost basis = 500
Bargain sale price = 750

Basis for sale = cost basis + (bargain sale price/list price)
$500 x ($750/$1500) = $250

Basis in gift = cost basis - basis for sale
$500 - $250 = $250

Company's gain = bargain sale price - basis for sale
$750 - $250 = $500

Charitable deduction = Basis in gift plus half of the gain foregone by selling at less than list price
$250 + ($750 - $250)/2 = $500

	ERTA	Pre-ERTA
Gain on sale	$500	$500
Charitable deduction	- 500	- 250
Taxable income	0	250
Cash received	750	750
Tax	0	- 115
Total benefit	750	635
Equipment cost	- 500	- 500
Net benefit to company	$ 250	$ 135

SOURCE: Coopers & Lybrand.

Some academic opinion holds that company officials who decide whether and how to contribute equipment are not fully abreast of the available tax benefits, even though company tax specialists are well informed. In this respect, for example, it appears that the bargain sale provisions of ERTA have been largely ignored.

Research and Development Tax Credit

ERTA created a 25 percent tax credit for incremental spending by industry on "research and experimentation," both in-house and under contract. The contract research, however, is restricted to work related to the taxpayer's trade or business, or basic research in colleges and universities. The credit is available for expenses incurred after June 30, 1981, and before January 1, 1986, unless new legislation is passed to extend the credit or make it permanent.* Money spent on scientific equipment under research contracts in academe qualifies for the credit.

As with the ERTA deduction for equipment donations, the research must be conducted in the United States and is restricted to the physical and biological sciences. Money for basic research may be paid either to the contracting universities or to a fund that awards grants for academic research. The requirements of the law preclude tax credits for research costs incurred by new ventures before they actually engage in business.

The 25 percent tax credit is computed on qualified research costs in excess of a floating average of research costs paid or incurred during the prior three years. In-house research costs are fully qualified, but only 65 percent of contract research costs is qualified. The three-year floating average of research costs cannot be less than 50 percent of current-year research costs. Thus the maximum tax credit is 12.5 percent of qualified, current-year research costs and 8.1 percent if only contract research costs are incurred. The calculation is illustrated in Table 10.

Company/University Considerations

The R&D tax credit reduces a company's costs for contract research at a university. Further, the costs qualified for in-house

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*The President's Tax Proposal of May 1985 would extend the credit for three years.

TABLE 10 Calculation of R&D Tax Credit

Qualified research expenses, 1985		
In-house		$640,000
Contract, nonbasic ($200,000 x 0.65)		$130,000
Contract, basic ($200,000 x 0.65)		$130,000
Total		$900,000
Less base-period research expenses		
1982	$ 600,000	
1983	$ 500,000	
1984	$ 700,000	
Total	$1,800,000	
Average	$ 600,000	(600,000)
Excess qualified expenses		$300,000
Rate		0.25
1985 Tax credit		$ 75,000

SOURCE: Coopers & Lybrand.

research include only wages and supplies, while the full costs of contract research are qualified. On the other hand, the tax credit is based on 100 percent of qualified costs for in-house research and only 65 percent of costs for contract research. Also, contract work at universities is restricted to basic research, which generally is a long-term effort, whereas corporate interests tend to be short term. The university and the company are both potential beneficiaries of patents arising from the research.

Additional considerations are involved but, on balance, the R&D tax credit does not appear to provide a special incentive for companies to contract for research at universities, as opposed to the qualified alternatives available. Exceptions would include companies that are committed to supporting basic research in academe, but might support more of it in light of the R&D tax credit.

STATE TAX INCENTIVES

Most states in recent years have adopted tax provisions designed to stimulate research at colleges and universities. The state incentives include adoption of the federal deduction for company contributions of scientific equipment to colleges or universities, enactment of provisions comparable to the federal deduction, allowance of the federal deduction and an additional state deduction, and enactment of a credit against tax for contributions of scientific property.

Adoption of the Federal Deduction

The federal deduction for contributions of scientific property to colleges and universities has been adopted by 34 states:

Arizona
Arkansas
Colorado
Connecticut
Delaware
Florida
Hawaii
Idaho
Illinois
Indiana
Iowa
Kansas
Missouri
Montana
Nebraska
New Hampshire
New Jersey
New Mexico
New York
North Dakota
Oklahoma
Oregon
Pennsylvania
Rhode Island

Kentucky
Maine
Maryland
Massachusetts
Michigan
Tennessee
Utah
Vermont
Virginia
West Virginia

Adoption of Deduction Other than Federal

California has adopted a provision essentially identical to the federal deduction for donations of scientific equipment to academe. As under the federal law, a corporation can deduct its basis in the contributed property plus half of the unrealized appreciation with a limit of twice its basis in the property.

Montana allows the federal deduction or a deduction equal to the fair market value of the property contributed, but not greater than 30 percent of the corporate taxpayer's net income.

In New Hampshire, a business that contributes scientific property may deduct, in lieu of the federal deduction, its basis in the contributed property plus 50 percent of the unrealized appreciation, or twice the basis of the property, whichever is less.

Massachusetts allows the federal deduction plus 25 percent of that deduction.

Adoption of Credits

Seven states, including some that have adopted the federal deduction for contributions of scientific equipment, in addition provide various types of tax credits. Idaho, Indiana, and North Dakota allow corporations a credit against tax as a means of stimulating contributions of scientific equipment to colleges and universities within the state. Louisiana allows corporations to elect a credit in lieu of a charitable deduction. Iowa, Wisconsin, and Minnesota allow a credit for increased research expenditures.

In determining expenditures that qualify for research credits, Iowa, Minnesota, and Wisconsin follow the federal definition of "qualified research expenses." The Iowa credit, which is effective for years beginning on or after January 1, 1985, is 6.5 percent of qualifying expenses incurred for research conducted within the state. If the credit exceeds the corporation's tax liability, Iowa refunds the excess with interest unless the corporation elects to apply the credit to its liability for the following year. The Minnesota credit is 12.5 percent of the first $2 million (and 6.5 percent of additional expenses) of the excess of qualified expenses over base-period expenses incurred for research conducted within the state. The Wisconsin credit is 5 percent of the corporation's qualified expenses incurred by research conducted within the state. Wisconsin also provides a 5 percent credit for the purchase of research equipment or construction of facilities to house it.

Idaho allows a credit of 50 percent of the aggregate amount of charitable contributions to institutions of higher education within the state during the year, but not exceeding 10 percent of the corporation's total Idaho tax liability or $500, whichever is less. Indiana also allows a credit of 50 percent of the aggregate amount of contributions during the year to institutions of higher education within the state, but not exceeding the corporation's tax liability minus all other credits, or 10 percent of the corporation's total adjusted gross income, or $1,000, whichever is less.

North Dakota allows a credit of 50 percent of charitable contributions to nonprofit private institutions of higher education within the state or to the North Dakota independent college fund, but not exceeding 20 percent of the corporation's income tax, or $2,500, whichever is less.

Louisiana allows corporations to elect a credit, in lieu of a deduction, for contributions of computer equipment to educational institutions within the state. The credit is 40 percent of the equipment's value or the corporation's total tax liability, whichever is less.

R&D LIMITED PARTNERSHIPS

Research and development limited partnerships are a source of risk capital that may permit individual investors to support academic research programs while sheltering some of their own income.[7] Investors can take current deductions for qualifying research expenditures; subject to certain conditions, they can pay tax at capital gains rates rather than ordinary income rates on royalties or on the sale of patent rights or patentable property.

An R&D limited partnership may include a partner (which could be a university) that contributes ideas or potential products, while other partners contribute capital to finance the necessary research and development. The university need not become a partner, but could license or assign inventions or know-how to the partnership for lump-sum cash payments or royalties. The partnership could contract with the university to perform research whether or not the university had previously provided anything to the partnership.

The partners would share the income from the sale or licensing of products or patents developed. Royalties or capital gains received by the university would not be unrelated business income, nor would fees paid to the university for research performed.

R&D limited partnerships in which the university is a partner potentially have several disadvantages:

- Much university research is more basic than is required for a partnership making high-risk investments in the hope of commercial return.
- The law in this area is still unsettled in many respects, including issues of potential liability.
- A limited partnership offering is a securities offering governed by federal and state law and regulations. Legal fees, brokerage commissions, and general partners' fees are substantial.
- R&D credits provided by ERTA for contract research are not available to a partnership unless it is engaged in a trade or business, intends to use the products developed in that trade or business, and does not intend to transfer the products for license or royalty payments. To be considered engaged in a trade or business, the partnership must be soliciting customers to purchase a product or service, but most partnerships do not solicit customers until after they have developed a product or service.

R&D limited partnerships have not been widely embraced by the academic community, although they have attracted a good deal of interest. The study team encountered no instances of universities' having procured scientific equipment through R&D limited partnerships.

LEASING

For-profit entities that lease equipment to colleges and universities may be able to take advantage of the accelerated depreciation (ACRS) provisions introduced by ERTA to shelter from taxes a part of their income from leasing. (See Chapter 4 for detailed discussion of leasing.) Investment tax credits are not available, however, to for-profit entities that lease to colleges and universities, which is a strong disincentive for such arrangements.

The Tax Reform Act of 1984 reduced the accelerated depreciation benefits previously available to lessors by increasing the number of years for depreciating equipment leased to colleges and universities and by providing that the equipment be depreciated using the straight-line method. The act excludes leasing arrangements for specific types of equipment from the new constraints. Certain high-technology equipment--including computers and peripheral equipment, sophisticated telephone station equipment installed on campus, and advanced medical equipment--can be depreciated by the lessor using normal ACRS rules if the lease period is five years or less. If the lease period is more than five years, depreciation is on a straight-line basis over five years.

DEVELOPING A DONATION STRATEGY

Donation transactions examined during this study (Appendix J) suggest a number of actions that could help colleges and universities to obtain donations of scientific equipment. In particular, it appears that involvement of academic representatives (e.g., development office people, department heads, and principal investigators) with their counterparts in prospective donor companies is vital to building the relationships needed to obtain regular contributions. In addition, colleges and universities that wish to develop donation strategies might consider the following activities:

- Target the manufacturers of equipment most needed by the institution.
- Prepare a description of the university's plans for using the equipment for presentation to prospective donors. The description should include information such as the research planned and the number and background of students and faculty who will be involved. In this respect, many companies expect to receive a written proposal before donating equipment.
- Prepare a description of the mutual benefits of donating equipment. These benefits include the long-range value of strengthening the research and academic programs of the university. More immediate benefits for prospective donors would include:
    -Research programs that are making scientific advances in which the donor is interested.
    -Introduction of the donor's products to potential buyers.
    -Students as potential employees.
    -Federal and state tax incentives that reduce the total cost of donating equipment.
    -Feedback from students and faculty as a source of product improvement and development.
    -Willingness of academic investigators to permit donors to demonstrate to potential customers the use being made of their equipment and the scientific advances being obtained with it.

RECOMMENDATIONS

The effects of ERTA have been studied extensively almost since its passage, primarily with a view to deciding whether the

R&D tax credit should be extended beyond its statutory expiration date, December 31, 1985, and in what form.[5,8] Although many believe that the tax credit has a positive effect, these studies have not produced clear-cut answers for several reasons: the act has been in effect only since August 1981; its effects are entangled with other economic variables in a complex manner; and the uncertain future of the act may have skewed its effects.

The examination of ERTA also has produced views on the value of the equipment-donation deduction, which is permanent under the act. The Council for Financial Aid to Education, as noted earlier, believes that ERTA has contributed significantly to corporate giving of scientific equipment to academe. Similarly, the National Science Foundation has said that both the R&D tax credit and the deduction for donations of equipment "apparently have helped to stimulate the recent surge of industry support for university science and engineering."[9]

The consensus appears to be that ERTA, suitably modified, should indeed spur technology, in part by fostering support for academic research and scientific equipment. We agree with this view. We believe also that colleges and universities could seek more aggressively to capitalize on available tax benefits, federal and state, in soliciting donations of equipment.

We recommend...

1. **That industry take greater advantage of the tax benefits provided by the Economic Recovery Tax Act (ERTA) of 1981 for companies that donate research equipment to universities and fund academic research.** Universities' experience with industry indicates that company officials may not be fully aware of the benefits available, although company tax specialists generally are well informed.
2. **That universities seek donations of research equipment more aggressively by developing strategies that rely in part on the tax benefits available to donors.** Sound strategies would stress both federal and state tax benefits as well as other important benefits to both donor and recipient.
3. **That Congress modify ERTA so that...**

...equipment qualified for the charitable donation deduction include computer software, equipment maintenance contracts and spare parts, equipment in which the cost of parts not made by the donor exceeds 50 percent of the donor's costs in the equipment, and used equipment that is less than three years old. Computers are properly viewed as computing systems, which are incomplete without software. Maintenance of scientific equipment is costly to the point where universities have declined donations of equipment because they could not afford to maintain it. Makers of sophisticated equipment rely primarily on their technological knowledge, not their ability to make parts. Thus the limit on parts from outside suppliers is unrealistic, provided that the manufacturer is in fact in the business of developing and making scientific equipment.

...the provisions on the R&D tax credit are made permanent, with revision to create an additional incentive for companies to support basic research in universities. Equipment acquired under research contracts qualifies for the credit, but ERTA currently provides the same incentive for companies to contract for research in academe as for research by other qualified organizations.

...the social and behavioral sciences are made qualified fields of academic research in terms of the equipment donation deduction and the R&D tax credit. The social and behavioral sciences contribute to the application and utilization of science and technology, and they rely increasingly on research instrumentation.

...qualified recipients of equipment donations and R&D funding, in terms of ERTA tax credits, include research foundations that are affiliated with universities but remain separate entities. Some state universities have established such foundations to receive and dispose of donated equipment because they cannot dispose of it themselves without legislative consent.

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Appendixes

APPENDIX A: R&D EXPENDITURES AT UNIVERSITIES AND 1953-1983

FY	Total	Fed. Govt.	State/ Local Govts.	Indus- try	Inst. Funds	All Other
Current Dollars in Millions						
1953	255	138	37	19	35	26
1954	290	160	42	22	38	28
1955	312	169	47	25	41	30
1956	372	213	53	29	43	34
1957	410	229	60	34	49	38
1958	456	254	68	39	53	42
1959	526	306	76	39	58	47
1960	646	405	85	40	64	52
1961	763	500	95	40	70	58
1962	904	613	106	40	79	66
1963	1,081	760	118	41	89	73
1964	1,275	917	132	40	103	83
1965	1,474	1,073	143	41	124	93
1966	1,715	1,261	156	42	148	108
1967	1,921	1,409	164	48	181	119
1968	2,149	1,572	172	55	218	132
1969	2,225	1,600	197	60	223	145
1970	2,335	1,647	219	61	243	165
1971	2,500	1,724	255	70	274	177
1972	2,630	1,795	269	74	305	187
1973	2,884	1,985	295	84	318	202
1974	3,023	2,032	307	96	370	218
1975	3,409	2,288	332	113	417	259
1976	3,729	2,512	364	123	446	285
1977	4,067	2,726	374	139	514	314
1978	4,625	3,059	414	170	623	359
1979	5,361	3,595	470	193	730	374
1980	6,060	4,094	494	236	829	409
1981	6,818	4,559	540	288	983	448
1982	7,261	4,749	586	326	1,098	503
1983	7,745	4,960	599	70	1,231	585

COLLEGES BY YEAR AND SOURCE OF FUNDS: FISCAL YEARS

FY	Total	Fed. Govt.	State/ Local Govts.	Industry	Inst. Funds	All Other
Constant Dollars in Millions						
1953	427	231	62	32	59	44
1954	480	265	70	36	63	46
1955	509	276	77	41	67	49
1956	591	338	84	46	68	54
1957	628	351	92	52	75	58
1958	682	380	108	58	79	63
1959	772	449	112	57	85	69
1960	929	582	122	57	92	75
1961	1,084	711	135	57	99	82
1962	1,267	859	149	56	111	92
1963	1,490	1,047	163	57	123	101
1964	1,738	1,250	180	56	140	113
1965	1,967	1,431	191	55	165	124
1966	2,228	1,639	203	55	192	140
1967	2,418	1,774	206	60	228	150
1968	2,611	1,910	209	67	265	160
1969	2,582	1,857	229	70	259	168
1970	2,565	1,809	237	67	267	181
1971	2,615	1,803	267	73	287	185
1972	2,630	1,795	269	74	305	187
1973	2,761	1,900	282	80	304	193
1974	2,698	1,813	274	86	330	195
1975	2,767	1,856	269	92	338	210
1976	2,828	1,905	276	93	338	216
1977	2,889	1,937	266	99	365	223
1978	3,077	2,035	275	113	414	239
1979	3,280	2,199	288	118	447	229
1980	3,412	2,305	278	133	467	230
1981	3,490	2,334	276	147	503	229
1982	3,469	2,269	280	156	525	240
1983	3,559	2,279	275	170	566	269

SOURCE: National Science Foundation, Academic Science/Engineering: R&D Funds Fiscal Year 1982 (Washington, D.C., 1984); and preliminary data for 1983.

APPENDIX B: CURRENT FUND EXPENDITURES FOR RESEARCH EQUIPMENT AT UNIVERSITIES AND COLLEGES BY SCIENCE/ENGINEERING FIELD AND SOURCE OF FUNDS: FISCAL YEARS 1982 AND 1983

(Dollars in Thousands)

Field	Total		Federally Financed			Nonfederal		
	1982	1983	1982	1983	Percent Change 1982-1983	1982	1983	Percent Change 1982-1983
Total	408,498	435,402	266,738	273,076	2.4	141,760	162,326	14.5
Engineering	65,861	75,171	43,220	48,837	13.0	22,641	26,334	16.3
Aeron. & Astron.	2,284	2,837	1,376	2,100	52.6	908	737	-18.8
Chemical	6,442	6,172	3,821	3,559	-6.9	2,621	2,613	-.3
Civil	5,164	6,086	2,823	3,422	21.2	2,341	2,664	13.8
Electrical	18,454	20,685	14,058	14,516	3.3	4,396	6,169	40.3
Mechanical	7,390	10,008	4,208	6,563	56.0	3,182	3,445	8.3
Other, NEC	26,127	29,383	16,934	18,677	10.3	9,193	10,706	16.5
Physical Sci.	78,126	79,153	62,642	62,137	-.8	15,484	17,016	9.9
Astronomy	5,127	4,243	3,941	3,465	-12.1	1,186	778	-34.4
Chemistry	33,323	32,826	24,927	23,632	-5.2	8,396	9,194	9.5
Physics	33,189	35,673	28,527	29,588	3.7	4,662	6,085	30.5
Other, NEC	6,487	6,411	5,247	5,452	3.9	1,240	959	-22.7
Environ. Sci.	28,321	31,123	18,423	19,643	6.6	9,898	11,480	16.0
Atmospheric	4,536	5,025	3,287	3,617	10.0	1,249	1,408	12.7
Earth Sci.	10,536	11,584	6,314	6,609	4.7	4,222	4,975	17.8

Oceanography	8,879	10,928	6,000	6,837	13.9	2,879	4,091	42.1
Other, NEC	4,370	3,586	2,822	2,580	-8.6	1,548	1,006	-35.0
Math/Comp. Sci.	15,228	18,177	9,832	11,705	19.1	5,396	6,472	19.9
Mathematics	2,556	2,668	1,617	1,476	-8.7	939	1,192	26.9
Comp. Sci.	12,672	15,509	8,215	10,229	24.5	4,457	5,280	18.5
Life Sciences	199,574	206,587	120,189	117,342	-2.4	79,385	89,245	12.4
Agric. Sci.	38,921	38,813	11,706	10,746	-8.2	27,215	28,067	3.1
Biol. Sci.	75,889	75,155	53,183	51,041	-4.0	22,706	24,114	6.2
Medical Sci.	78,809	85,942	51,547	51,546	.0	27,262	34,396	26.2
Other, NEC	5,955	6,677	3,753	4,009	6.8	2,202	2,668	21.2
Psychology	5,784	6,526	4,219	4,753	12.7	1,565	1,773	13.3
Social Sci.	7,143	8,938	2,907	2,912	.2	4,236	6,026	42.3
Economics	1,704	1,911	674	728	8.0	1,030	1,183	14.9
Polit. Sci.	765	767	312	319	2.2	453	448	-1.1
Sociology	2,056	1,462	948	939	-.9	1,108	523	-52.8
Other, NEC	2,618	4,798	973	926	-4.8	1,645	3,872	135.4
Other Sci. NEC	8,461	9,727	5,306	5,747	8.3	3,155	3,980	26.1

NEC, not elsewhere classified.

SOURCE: National Science Foundation, Academic Science/Engineering: R&D Funds Fiscal Year 1983 (In press), Preliminary Table B-60.

APPENDIX C: FEDERAL INSTRUMENTATION PROGRAMS

Agency, Program Title	Description
Department of Defense: DOD-University Research Instrumentation Program	Five-year program to upgrade university research instrumentation sponsored by Army Research Office, Office of Naval Research, and Air Force Office of Scientific Research. Program goals: - To stimulate and support basic research that furthers the technological goals of DOD. - To support the training of graduate students in the use of research equipment. Requests are not considered for instrumentation with a total cost to DOD of less than $50,000 or more than $500,000. Requests for specialized research configurations of computers that are devoted primarily to specific DOD research programs are considered, provided that the total government contribution to the purchase cost of the computer equipment does not exceed $300,000.

University Matching	Annual Volume of Funding
Matching is encouraged but is not required and is not included in the criteria used for evaluating proposals. DOD funds awarded cannot be used for buildings or facilities modification, although such costs when borne by the university or other funding source may contribute to matching. Set-up costs may be included, but costs for continued operation and maintenance must be met by normal research support mechanisms.	Fiscal year 1983 was Phase I of the program. Thirty million dollars was allocated equally among the three armed services for each year of the program. - 2,500 proposals were received totaling $645 million in funding requests. - 200 awards were made to more than 80 universities. Fiscal years 1984 and 1985 comprise Phase II. Sixty million dollars will be equally distributed over the two years.

Agency, Program Title	Description
Department of Energy: University Research Instrumentation Program	Program goal is to stimulate and support basic research in those universities with existing DOE support. Funds are provided for acquisition costs of instruments. Costs of renovation and installation, operation and maintenance, service contracts, and technical support are not provided. The usable life span of the equipment must be estimated and the institution's plans for ensuring its continued availability during the first five years must be demonstrated.
National Science Foundation: Astronomical Instrumentation and Development Program	Program provides support for development and construction of state-of-the-art detectors and data-handling equipment, procurement of detection and analysis systems for telescopes at institutions that presently lack such systems, development of interactive picture-processing systems, very long baseline interferometric instrumentation, and application of new technology and innovative techniques to astronomy.

University Matching	Annual Volume of Funding
No specific fraction of matching is specified, but the level of matching will be a factor in the evaluation of applications. Matching can include shipping/installation and/or the renovation/ modification of the physical space where the instrument will be located.	Five-year program projected to last through 1989. Fiscal year 1984 funding was $4 million. Fiscal year 1985 funding is $6 million.
Matching is not required.	Fiscal year 1981 funding was $5.9 million. Fiscal year 1982 funding was $6 million. Fiscal year 1983 funding was $6.7 million. Fiscal year 1984 funding was $9.6 million. Fiscal year 1985 funding is $7.9 million.

Agency, Program Title	Description
National Science Foundation: Biological Instrumentation Program	Program provides funds for purchase of multiple-user instruments in physiological, cellular, and molecular biology. Program supports the development of new instruments that will either extend current instrument capability in terms of sensitivity of resolution or will provide new and alternative techniques for detection and observation of physical or biological phenomena. Funds will not be provided for space renovation, installation, maintenance contracts, technical personnel, and operation of commercial instruments. However, the university must describe how maintenance and operation costs will be met. Personnel and shop costs may be requested for instrument development and construction.
National Science Foundation: Chemical Instrumentation Program	Program provides aid to universities and colleges in acquiring major items of multiuser instrumentation essential for conducting fundamental research in chemistry.

University Matching	Annual Volume of Funding
Matching is required. The exact amount (in the range of 25 to 50 percent) is negotiated with the university. Renovation of space and maintenance are acceptable as part of the university's matching only if accompanied by part of the purchase price.	Fiscal year 1983 funding was $5 million. Fiscal year 1984 funding was $6.2 million. Fiscal year 1985 funding is $7.4 million.
Matching is required, but the amount varies. In fiscal year 1984 the university share was 33 1/3 percent.	Fiscal year 1980 funding was $4.2 million. Fiscal year 1981 funding was $4.6 million. Fiscal year 1982 funding was $4.1 million. Fiscal year 1983 funding was $6.4 million.

Agency, Program Title	Description
National Science Foundation: Chemical Instrumentation Program (continued)	Program does not normally provide support for personnel, indirect costs, installation, or operating costs. When such support is necessary during the installation and start-up period for complex instrumentation, detailed justification must be provided. The university must provide information on the annual budget for maintenance and operation of the proposed instrument, other research support services and total operating budget, and technical support staff and maintenance expertise provided by the department. Proposals are evaluated on the basis of the ability of the department to ensure that the instrument will be well maintained and efficiently used.
National Science Foundation: Computer Research Equipment Grants	Program provides support for purchase of special-purpose equipment for computer research. The equipment must be necessary for the pursuit of specific research projects rather than intended to provide general computing capacity. It must be needed by more than one project and difficult to justify for one project alone. The total cost must be at least $10,000.

University Matching	Annual Volume of Funding
	Fiscal year 1984 funding totaled $10.2 million. - $1.3 million went to small schools with primarily undergraduate programs. - $80,000 was for a new program that provides funds to universities in states that have not fared well in funding. - $2.2 million was for regional instrumentation facilities. - Remainder of funding was for Ph.D.-granting institutions for equipment over $50,000. Fiscal year 1985 funding is about $10.2 million.
Universities must provide a minimum of 25 percent of the cost of the equipment and first-year maintenance as matching.	Fiscal year 1980 funding was $2 million. Fiscal year 1981 funding was $1 million. Fiscal year 1982 funding was $1.2 million. Fiscal year 1983 funding was $1.2 million. Fiscal year 1984 funding was $1.4 million.

Agency, Program Title	Description
National Science Foundation: Computer Research Equipment Grants (continued)	Funds for maintenance during the first year may also be requested. The university must provide a detailed plan for the maintenance and operation (M&O) of the instrument including the annual M&O budget that the department will allocate.
National Science Foundation: Earth Sciences Research Instrumentation Program	Program is intended to meet the need for specialized equipment that commonly is too expensive and of too broad a potential use to be justified by a regular research proposal. Program provides funds to purchase major research equipment, renovate and upgrade existing equipment, and develop new instruments that will extend current research capabilities. Support may be requested for regional facilities to provide access to large items of equipment by a broad segment of the research community. Personnel and shop costs may be requested for equipment development and construction. The costs of space renovation, installation, maintenance, technical personnel, and operation of commercial equipment ordinarily are not supported.

University Matching	Annual Volume of Funding
	Fiscal year 1985 funding is about $1.5 million.
No specific fraction of matching is specified, but the university contribution is a determining factor in the award. The university is encouraged to assume the costs of space renovation, installation, and maintenance as matching in addition to part of acquisition cost of the instrument.	Prior to 1983, funding was variable with most money coming from small research projects. Funding for fiscal years 1980 to 1982 was about $750,000 per year. Fiscal year 1983 funding was $2.5 million. Fiscal year 1984 funding the was $5 million. Fiscal year 1985 funding is $5 million.

Agency, Program Title	Description
National Science Foundation: Earth Sciences Research Instrumentation Program (continued)	The university must describe the provisions for maintenance of the equipment or facility and the source of funds to meet the costs of maintenance and operation. The ability of the institution to operate and maintain the equipment is a determining factor in the award.
National Science Foundation: Engineering-Automation Instrumentation and Sensing Systems Program	New program that supports research in instrumentation for all engineering disciplines. The scope will cover everything from fundamental research on instrumentation questions to research leading to development of instrumentation and/or proof of concept.
National Science Foundation: Engineering Research Equipment Grants	Program provides funds to purchase new equipment or to upgrade existing equipment. The equipment should be necessary for pursuit of specific research projects in areas normally supported by the engineering directorate. Funds are not provided for space renovation, installation, maintenance contracts, and the operation of commercial instruments. However, the university must provide a detailed statement of its intention to provide

University Matching	Annual Volume of Funding
Matching is required, but is negotiated on a case-by-case basis. The university share is expected to be at least 33 1/3 percent of the total cost of each item of equipment.	Fiscal year 1980 funding was $2.86 million. Fiscal year 1981 funding was $1.8 million. Fiscal year 1982 funding was $1.9 million. Fiscal year 1983 funding was $3.9 million. Fiscal year 1984 funding was $7.3 million. Fiscal year 1985 funding is about $7 million.

Agency, Program Title	Description
National Science Foundation: Engineering Research Equipment Grants (continued)	these facilities, if required. The ability of the university to provide essential supporting facilities and maintenance is a determining factor in the award.
National Science Foundation: Materials Research Instrumentation Program	Program provides support for purchase of major instruments needed for materials research and for development of new instruments that extend current measurement capability. Costs of space renovation, installation, maintenance contracts, technical personnel, and operation of commercial instruments ordinarily are not supported. Personnel and shop costs may be requested for instrument development and construction. The ability of the university to operate and maintain the instrument and the adequacy of shop and electronics support are determining factors in the award.
National Institutes of Health Division of Research Resources: Research Support Shared Instrumentation Grants Program	Program began in 1982 in response to recognition of the long-standing need in the biomedical research community to cope with rapid technological advances in instrumentation and the

University Matching	Annual Volume of Funding
Matching is required, but no specific fraction is specified. The level of funds provided by the university is a determining factor in the award. Assumption by the university of costs of space renovation, installation, maintenance contracts, and technical personnel is encouraged.	Fiscal year 1983 funding was $4 million. Fiscal year 1984 funding was $6.5 million. Fiscal year 1985 funding is $6.5 million.
Matching is not required.	Fiscal year 1982 funding was $3.7 million. Fiscal year 1983 funding was $14 million. Fiscal year 1984 funding was $19.7 million.

Agency, Program Title	Description
National Institutes Health Division of Research Resources: Research Support Shared Instrumentation Grants Program (continued)	rapid rate of obsolescence of of existing equipment. Program is a subprogram of the Biomedical Research Support Grant, and supports instrumentation used by three or more investigators. Program provides funds to purchase or update expensive shared-use equipment which is not generally available through other NIH mechanisms. Maximum award is $300,000. Program funds the acquisition of equipment only. The institution must meet those costs required to place the equipment in operational order as well as maintenance, support personnel, and service costs. If the funds requested do not cover the total cost of the instrument, an award will not be made unless the remainder of the funding is assured. The institution's ability to provide continued maintenance of the equipment is a determining factor in the award.
National Institutes of Health Division of Research Resources: Biomedical Research Technology Program	Program funds regional and national shared instrumentation centers. Its purpose is to develop and provide access to very sophisticated instrumentation and

University Matching	Annual Volume of Funding
	Fiscal year 1985 funding is $31.8 million.
Matching is not required, although some institutional contribution is encouraged.	Fiscal year 1980 funding was $15 million. Fiscal year 1981 funding was $16.8 million.

Agency, Program Title	Description
National Institutes of Health Division of Research Resources: Biomedical Research Technology Program (continued)	technology needed to solve basic biomedical and clinical research problems. These resources include core research programs for instrument and methods development, collaborative research programs, and programs providing service for users in biomedical research. The program provides funds for initial instrument purchase and installation. The grant pays the full cost of the core research not otherwise supported and supports aspects of the program required to provide access to outside users, such as personnel, maintenance, and supplies. Awards exceed $300,000, the ceiling for the BRS Shared Instrumentation Grants Program. The scope of the Biomedical Research Technology Program is broader--its facilities are located to maximize accessibility to a particular region rather than one university or department.
National Institutes of Health Division of Research Resources: Minority Biomedical Research Support Program	Program provides funds to institutions having an MBRS award for acquisition of new equipment or upgrading of existing equipment.

University Matching	Annual Volume of Funding
	Fiscal year 1982 funding was $17.7 million. Fiscal year 1983 funding was $23.5 million. Fiscal year 1984 funding was $31.4 million. Fiscal year 1985 funding is estimated to be $30.9 million.
Matching is not required.	Fiscal year 1983 funding was $1.3 million. Fiscal year 1984 funding was $1 million.

Agency, Program Title	Description
National Institutes of Health Division of Research Resources: Minority Biomedical Research Support Program (continued)	There is no limit on the cost of instrumentation requested; however, the maximum award is $135,000. When the total cost of the instrument exceeds $135,000, an award will not be made unless the remainder of the funding is assured. Support for construction, renovation, maintenance, or personnel is not provided. However, the institution's commitment to support of operation and maintenance of the instrument is a determining factor in the award.
National Institutes of Health National Institute of General Medical Sciences: Shared Instrumentation Program	Program was begun in 1978 to provide funds for purchasing new or updating existing major analytical research instruments that might not be justified fully for a single project, but can serve several projects on a shared basis. Program goals are to provide NIGMS grantees with better access to modern instrumentation and to promote the diffusion of new techniques among potential users. The program provides funds for instruments in the $30,000 to $100,000 price range. When funds exceeding that amount are requested, the application is passed automatically to the DRR Shared Instrumentation

University Matching	Annual Volume of Funding
	Fiscal year 1985 funding is $1 million.
The university is expected to demonstrate its commitment to the instrument by contributing at least half the costs for maintenance and technical support personnel. In addition, the university must provide for installation and any needed renovation of existing facilities.	Funding for fiscal years 1979 and 1980 was $9 million. No awards were made in fiscal year 1981. Fiscal year 1982 funding was $1.3 million. Fiscal year 1983 funding was $600,000. Fiscal year 1984 funding was $200,000. Fiscal year 1985 funding is $270,000.

Agency, Program Title	Description
National Institutes of Health National Institute of General Medical Sciences: Shared Instrumentation Program (continued)	Program. The NIGMS program will contribute to both instrument maintenance and support personnel. The amount of funding extended for the purpose is determined by customary review groups.

APPENDIX D: ANALYSIS OF LOAN SUBSIDY PROGRAMS

The potential utility of a loan subsidy program for scientific equipment is analyzed here in terms of hypothetical models and cost comparisons. Our assumptions about cost components are based on the experience of the Guaranteed Student Loan (GSL) Program.* The category of special allowance in the GSL program is called interest subsidy in this analysis. (The GSL category named interest subsidy is the interest paid while the student is in school and, hence, is not relevant to this analysis.)

We examined three alternatives: loan guarantee, loan guarantee with interest subsidy, and direct loan with low interest. The analysis uses the following assumptions:

- Market interest rate is 14 percent.
- Tax-exempt interest rate is 7 percent.
- Interest subsidy (the amount necessary to guarantee the same rate as tax-exempt borrowing) is 7 percent.
- Funding to be made available to the universities to purchase R&D equipment is to be increased by $100 million, about 23 percent of total spending on academic equipment in 1983.
- Administrative, insurance, and incidental costs of the loan programs to the government approximate 22 percent of total costs, which is the experience of the Guaranteed Student Loan Program.

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*Touche Ross & Co., Study of the Costs and Flows of Capital in the Guaranteed Student Loan Program, Final Report to the National Commission on Student Financial Assistance (Washington, D.C., March 1983).

LOAN GUARANTEE

Federal assistance in the form of a loan guarantee would primarily affect the credit rating of some universities, thus increasing their access to capital and reducing their interest expenses. This reduction, however, is likely to be relatively small. In addition, a loan guarantee program is not likely to increase total resources significantly.

LOAN GUARANTEE WITH INTEREST SUBSIDY

The loan guarantee with interest subsidy alternative was designed to increase the total capital available to universities for equipment, rather than to reduce the cost of debt for those already participating in the credit markets for that purpose. If an interest subsidy reduces the cost of funds to below the tax-exempt rate the strongest universities can obtain in financial markets, they might substitute federal loans for their own money. Universities that are less solid financially, or are in states that do not authorize the use of tax-exempt bonds for equipment purchases, could thus be crowded out. In addition, the total resources available to all universities might increase very little, if at all. The interest subsidy in this alternative, therefore, was pegged to achieve an interest rate roughly the equivalent of the tax-exempt rate.

Amortization of a $100 million, five-year loan at 14 and 7 percent interest and calculation of the interest subsidy are shown in Table D-1. The subsidy is a residual of interest payments calculated at 14 percent (assumed market rate) and 7 percent (assumed tax-exempt rate) and discounted at 7 percent. The interest subsidy would more than double if the repayment period were increased to 14 years.

The relative proportions of the costs to the government in this alternative are shown in Table D-2, which is based partly on the GSL program. As the table shows, the interest subsidy constitutes 77 percent of the total cost. Administrative costs for the GSL program tend to be relatively small, between 2 and 3 percent. It is possible, however, that in a smaller program, such as a loan guarantee with an interest subsidy, the administrative costs would be somewhat higher. The overall increase in cost to the government, nevertheless, should be negligible. Federal reinsurance, which accounts for 16 to 18 percent of cost in the GSL program, might be lower in a program of loan guarantees with interest subsidy, because most loans would be made to institutional borrowers rather than individuals. A reduction of 3 percent would

TABLE D-1 Amortization Table for $100 Million, Five-Year Loan

Year	Principal	Payment	Interest	Repayment of Principal	Balance
Annual Rate of 14 Percent					
1	$100,000,000	$29,128,355	$14,000,000	$15,128,355	$84,871,645
2	84,871,645	29,128,355	11,882,030	17,246,325	67,625,320
3	67,625,320	29,128,355	9,467,545	19,660,810	47,964,510
4	47,964,510	29,128,355	6,715,031	22,413,324	25,551,186
5	25,551,186	29,128,355	3,577,166	25,551,166	(3)
Annual Rate of 7 Percent					
1	$100,000,000	$24,389,069	$ 7,000,000	$17,389,069	$82,610,931
2	82,610,931	24,389,069	5,782,765	18,606,304	64,004,627
3	64,004,627	24,389,069	4,480,324	19,908,745	44,095,882
4	44,095,882	24,389,069	3,086,712	21,302,357	22,793,525
5	22,793,525	24,389,069	1,595,547	22,793,522	3

Year	Difference in Payment Required	Present Discounted Value (7 Percent Discount Rate)
1	$ 4,739,286	$ 4,429,239
2	4,739,286	4,139,476
3	4,739,286	3,868,669
4	4,739,286	3,615,579
5	4,739,286	3,379,045
Present value of payment difference stream (interest subsidy)		$19,432,008

SOURCE: Coopers & Lybrand.

TABLE D-2 Cost to the Government of a $100 Million, Five-Year Loan Program with Interest Subsidy

	Cost (dollars)	Percentage
Interest subsidy	19,432,008	77
Reinsurance	4,290,184	17
Administrative	504,727	2
All other	1,009,455	4
Total gross	25,236,374	
Total offsets	2,894,612	
Net outlays	22,341,762	

SOURCE: Coopers & Lybrand.

be expected to save the government $807,640 on a $100 million loan program.

DIRECT LOAN PROGRAM

In the direct loan alternative, the government is assumed to raise $100 million, which it then lends to universities at an interest rate of 7 percent, the rate available in the tax-exempt debt market. Compared with the loan guarantee with interest subsidy, this alternative entails small additional transaction costs, to raise the $100 million, and administrative costs, to manage the two streams of payables and receivables. On balance, these additional costs are expected to be negligible.

The key finding of our projections for the direct loan alternative is that the present discounted value of the cost to the government is the same, $19,432,008, as for the loan guarantee with interest subsidy described above, if the government borrows at the 14 percent rate assumed for the previous projections (see Table D-1). The reason is that the actual amount of subsidy--the difference between annual repayments from borrowers at a 7 percent rate, and the combined principal and interest (at 14 percent) falling due each year--is the same in both programs. If the government is able to borrow the $100 million at a lower rate of interest (as it might well be able to do in the Treasury bill market), then the direct loan program is the cheaper of the two.

The direct loan program does involve certain political considerations. The first is that the additional government borrowing would represent an increase in the national debt. The increase is essentially cosmetic, however, as the amount borrowed would be repaid, except for the interest subsidy, as in the loan guarantee with interest subsidy program. The second consideration relates to who receives the subsidies from the government. In a direct loan program, it would be the investors in the Treasury bill market (or other lenders to the government). In a loan guarantee with interest subsidy program, the beneficiaries would be the banks lending low-interest money to the universities by receiving federal payments, making total amounts received equal to receipts from loans at market rates.

APPENDIX E: REPRESENTATIVE STATE REGULATIONS

Purchasing Controls	Financing Controls	Utilization Controls
California[a]		
All contracts for purchase of equipment approved by Dept. of General Services.	Higher education financing authority finances facilities and equipment for independent institutions.	No formal controls. General requirements of demonstrable public purpose.
Competitive procurement for all purchases in excess of $100.	Public institution financing for facilities may include all equipment in original construction or renovations.	Joint public-private ventures increasingly common.
Special approvals required for data processing and telecommunications equipment.	Public institution financing may incorporate reserves for additions and improvements; unclear if replacement may be included.	
Act applies only to public institutions.	Legislation introduced to allow public institutions to participate in pooled equipment issues.	

Purchasing Controls	Financing Controls	Utilization Controls
California (continued)		
Public institution boards have delegated authority to approve contracts up to defined limits.	Legislation introduced for high technology financing for public and independent higher education.	
Connecticut[b]		
All contracts by Dept. of Admin. Services, unless DAS authorizes other state agency to acquire directly.	Health & education facilities authority finances equipment and facilities for public and independent institutions.	Public and independent institutions may jointly use any facilities and equipment.
DAS established equipment standardization rules for all agencies. May authorize noncompetitive procurement in emergencies.	Equipment financing only as incident to facilities projects.	Extensive use of quasi-public corporations for ownership of property both tangible and intellectual.
Competitive procurement required for purchases above $6,000;		

Purchasing Controls	Financing Controls	Utilization Controls
Connecticut (continued)		
below $6,000 preferred; not required below $300.		
Special rules for data processing and "similar" equipment set by DAS, but may waive for other agencies.		
Georgia[c]		
All equipment purchases through Dept. of Admin. Services from certified sources, with preference for items produced in-state.	Public and independent institutions have separate higher education financing authorities.	No explicit limitations.
DAS set standard specifications for all equipment.	For private institutions, equipment financed only as part of original construction or renovation.	All property of public universities vests with Board of Regents but can be alienated only with approval of Governor.

Purchasing Controls	Financing Controls	Utilization Controls
Georgia (continued)		
Competitive procurement except if cost under $500 or continuing procurement.	For public institutions, equipment may be separately financed.	
Technical instruments and supplies exempted from most purchasing controls, as is acquisition from U.S. govt.		
DAS administers statewide telecommunications and EDP, but universities exempted from mandatory provisions.		
Illinois[d]		
Purchasing carried out by each public agency, except for specified categories.	Educational facilities authority finances facilities and equipment of independent institutions.	Higher Education Cooperation Act encourages interinstitutional cooperation; has been defined to extend to cooperation between institutions and other public or nonprofit entities.

Purchasing Controls	Financing Controls	Utilization Controls
Illinois (continued)		
Competitive procurement required for equipment over $2,500; preferred for all.	EFA may issue pooled equipment bonds.	Statutory limitations on nonpublic use of equipment.
Special controls for leasing of computer and telecommunications equipment.	Public institutions may issue revenue bonds; other financing through general obligations of state.	
	Statutory limitation on term of all contracts, including leases; one-year maximum or appropriations period, with some exceptions.	
	Capital development authority finances public facilities, including appurtenant equipment.	
Iowa[c]		
Board of Regents conducts purchasing for public institutions.	Financing of equipment at public institutions only as part of facilities construction project.	No direct controls.

Purchasing Controls	Financing Controls	Utilization Controls
Iowa (continued)		
Advertise competitively for all procurements in excess of $25,000. Limited competition for other procurement. Operating funds requisitioned on as-needed basis within appropriated sums.	No private institution financing agency.	
Kentucky[f]		
Institutions may elect to control own purchasing bounded by provisions of the state's Model Procurement Code. Smaller institutions may choose to use services of central stores, if greater savings can be achieved by having state order large quantities of certain items.	Institutions have responsibility for financing of capital projects.	No state controls--institutions may have authority to provide best use of money for services rendered and goods purchased.

Purchasing Controls	Financing Controls	Utilization Controls
Maryland[g]		
Centralized control for all equipment acquisitions for public institutions, through Board of Public Works.	Public institutions may capitalize equipment and finance through general obligation bonds if useful life in excess of 15 years.	Strong statutory limitations on public university involvement in for-profit ventures.
Preference for Maryland suppliers.	No higher education facilities authority for private institutions. Some limited use of industrial revenue bond authority for comparable purposes.	
Special rule for acquisition of computers and software, with additional approval steps. (But legislation introduced to exempt all computer procurements for academic or research purposes.)	Extensive development of joint venture financing.	
Competitive sealed bids for items in excess of $750; agencies can adopt "small procurement procedures" for lesser amounts.		

Purchasing Controls	Financing Controls	Utilization Controls
Maryland (continued)		
Strict review of equipment requisition by BPW, with power to recommend substitution of "equivalents."		
New York[h]		
Purchasing by individual public system (State Univ. of NY, City Univ. of NY, statutory colleges, community college dists).	Public financing agencies (State Univ. Const. Fund and City Univ. Const. Fund) may finance equipment as well as facilities.	Dependent upon public system.
Purchases under $100 exempt from competitive procurement; up to $5,000 need not advertise for bids; beyond $5,000 full competitive procurement. State Univ. Const. Fund and CUNY and Dormitory Auth. equivalents may exempt contracts under $20,000.	State Dormitory Authority may finance facilities for lease to private institutions, with appurtenant equipment.	

Purchasing Controls	Financing Controls	Utilization Controls
North Carolina[i]		
Secretary of Administration receives requisitions and makes purchases on behalf of state agencies, except Univ. of North Carolina and community colleges.	Higher education facilities authority proposed but recently defeated in referendum.	Extensive joint public-private activity.
Competitive sealed bids for all purchases in excess of $5,000; Advisory Budget Committee sets requirements for lesser amounts.	Public financing includes equipment appurtenant to facilities project.	Extensive use of quasi-governmental entities.
Virginia[j]		
All purchases made with state funds must be by Dept. of General Services.	Higher education facilities authority finances equipment as part of facilities project, but may allow acquisition of equipment for "a period" after construction is completed.	Statutory authority for public institutions to contract with private institutions for services and facilities.

Purchasing Controls	Financing Controls	Utilization Controls
Virginia (continued)		
DGS standardizes all purchases and must grant waivers for exceptions.	Industrial Revenue Bond Act may be used to equip educational facilities (private), separate from construction.	Legislation approved for joint public institution-private sector high tech R&D activities; created Center for Innovative Technology.
DGS may exempt purchases below specified amount from its direct control, and may exempt classes of equipment.	Public institution financing of equipment as part of construction project.	
DGS may authorize state agencies to purchase directly; has done so for most higher education.		
All contracts competitive, with preference for Virginia goods.		
Agencies may set procedures for noncompetitive procurement for items less than $10,000, or available from a sole source.		

[a] Cal. Pub. Con. Code sections 10290-12121, 20650-20659; Cal. Educ. Code sections 81651-56, 81800-10, 94100-94213; Cal. Gov't. Code sections 11005, 13332-13332.16.

[b] Conn. Gen. Stat. Ann. sections 3-116a, 3-116b, 4-23j, 4-23k, 4-34, 4-36, 4-69 to 4-124, 10a-22, 10a-89, 10a-98 to 10a-98g, 10a-110 to 10a-110g, 10a-126 to 10a-136, 10a-150, 10a-176 to 10a-198.

[c] Ga. Code sections 20-3-53 to 20-3-60, 20-3-150 to 20-3-214, 50-5-10 to 50-5-11, 50-5-50 to 50-5-81, 50-5-160 to 50-5-169, 50-16-81, 50-16-160 to 50-16-162.

[d] Ill. Rev. Stat. ch. 172, sections 213.1 et seq., 307 et seq., 751 et seq.; ch. 144, sections 68 et seq., 181 et seq., 351 et seq., 1201 et seq., 1301 et seq.

[e] Iowa Code Ann. ch. 262, ch. 262A, ch. 263A.

[f] Ky. Rev. Stat. section 164.026; ch. 45A.

[g] Md. Ann. Code art. XII, sections 12-101 to 12-106; art. XVII, sections 17-101 to 17-107.

[h] N.Y. Educ. Law, tit. 1, art. 8-A, sections 370, 376; tit. 7, art. 125, sections 6201, 6213; tit. 7, art. 125-B, sections 6270, 6275.

[i] N.C. Gen. Stat. sections 116-53, 143-2 to 143-7, 143-49 to 143-56.

[j] Va. Code sections 2.1-422 to 2.1-548, 11-35 to 11-80, 15.1-1373 to 15.1-1391, 23-9.10:3, 23-14 to 23-30.03, 23-30.39 to 23-30.58.

SOURCE: Coopers & Lybrand.

APPENDIX F: REPRESENTATIVE STATE STATUTES AUTHORIZING THE ISSUANCE OF BONDS TO FUND HIGHER EDUCATION FACILITIES

State/Statutes	Equipment Included If Part of New Construction or Major Renovation	After-Acquired Equipment* Includable as Separate Project
ALABAMA Educational Building Authorities Act, Ala. Code Sec. 16-17-1 to 16-17-19 (1983)	Yes	Yes
ARIZONA Industrial Development Plans for Municipalities and Counties, Ariz. Rev. Stat. Ann. Sec. 9-1151 to 9-1196 (1983)	Yes	No
CALIFORNIA California Educational Facilities Authority Act, Cal. Educ. Code Sec. 94100-94213 (1983)	Yes	Yes
CONNECTICUT Connecticut Health and Educational Facilities Authority, Conn. Gen. Stat. Ann. Sec. 10a-176 to 10a-198 (1983)	Yes	Pending
DISTRICT OF COLUMBIA Taxation and Fiscal Affairs, D.C. Code Ann. Sec. 47-321 to 47-334 (1983)	Yes	Yes

State/Statutes	Equipment Included If Part of New Construction or Major Renovation	After-Acquired Equipment Includable as Separate Project
FLORIDA Higher Education Facilities Authority Law, Fla. Stat. Ann. Sec. 243.18 - 243.40 (1983)	Yes	No
GEORGIA Private Colleges and Universities Authority Act, Ga. Code Ann. Sec. 20-3-200 to 20-3-214 (198); Georgia Education Authority (University) Act, Ga. Code Ann. Sec. 20-3-150 to 20-3-181 (1983)	Yes	Varies**
ILLINOIS Educational Facilities Authority Act, Ill. Rev. Stat. ch. 144, Sec. 1301-1326 (1981); Board of Regents Revenue Bond Act of 1967, Ill. Rev. Stat. ch. 144, Sec. 351-363 (1983); Bonds for Permanent Improvements at State Educational Institutions Ill. Rev. Stat. ch. 127, Sec. 307-313 (1983); Capital Development Bond Act of 1972, Ill. Rev. Stat. ch. 127, Sec. 751-765 (1983); State Colleges and Universities Revenue Bond Act of 1967, Ill. Rev. Stat. ch. 144, Sec. 1201-1213 (1983); Illinois Building Authority Act, Ill. Rev. Stat. ch. 127, Sec. 213.1-1 to 213.16 (1983)	Yes	Varies**

State/Statutes	Equipment Included If Part of New Construction or Major Renovation	After-Acquired Equipment Includable as Separate Project
INDIANA Indiana Educational Facilities Authority Act, Ind. Code Ann. Sec. 20-12-63-1 to 20-12-63-29 (1983)	Yes	Yes
IOWA State Universities Buildings Facilities and Services Revenue Bonds, Iowa Code Ann. Sec. 262A.1-262A.13; Medical and Hospital Buildings at University of Iowa, Iowa Code Ann. Sec. 263A.1-263A.11	Yes	No
KENTUCKY Property and Buildings Commission, Ky. Rev. Stat. Sec. 56.440-56.495	Yes	No
MINNESOTA Minnesota Higher Education Facilities Authority, Minn. Stat. Ann. Sec. 136A.25-136A.55 (1983)	Yes	Pending
NEW JERSEY New Jersey Educational Facilities Authority Law, N.J. Rev. Stat. Sec. 18A:172A-1 to 18A:72A-39 (1983)	Yes	No

State/Statutes	Equipment Included If Part of New Construction or Major Renovation	After-Acquired Equipment Includable as Separate Project
NEW YORK City University Construction Fund Act, N.Y. Educ. Law Sec. 6270-6282; State University Construction Fund Act, N.Y. Educ. Law Sec. 370-384; Board of Higher Education in the City of New York, N.Y. Educ. Law Sec. 6201-6216; New York Dormitory Authority Act, N.Y. Pub. Auth. Law Sec. 1675-1694	Yes	Varies**
OHIO Higher Educational Facility Commission, Ohio Rev. Code Ann. Sec. 3377.01-3377.16	Yes	No
SOUTH CAROLINA Educational Facilities Authority Act for Private Nonprofit Institutions of Higher Learning, S.C. Code Ann. Sec. 59-109-10 to 59-109-180	Yes	No
TEXAS Higher Education Authority Act, Tex. Educ. Code Ann. Sec. 53.01-53.46	Yes	No

State/Statutes	Equipment Included If Part of New Construction or Major Renovation	After-Acquired Equipment Includable as Separate Project
VERMONT Educational and Health Buildings Financing Agency, Vt. Stat. Ann. tit. 16, Sec. 3851-3862	Yes	No
VIRGINIA Industrial Development and Revenue Bond Act, Va. Code Sec. 15.1-1373 to 15.1-1391 (1983); Bonds and Other Obligations, Va. Code Sec. 23-14 to 23-30.03 (1983); Educational Facilities Authority Act, Va. Code Sec. 23-30.39 to 23-30.58 (1983)	Yes	Yes
WASHINGTON Washington Higher Education Facilities Authority, Wash. Rev. Code Ann. Sec. 28B.07.010-28B.07.920 (1984); Wash. Rev. Code Ann. Sec. 28B.10.300-28B.10-335 (1984)	Yes	No

* Equipment acquired after construction of the facility.

** At least one, but not all, of the identified statutes in these states extends to after-acquired equipment.

SOURCE: Coopers & Lybrand.

APPENDIX G: IOWA STATE UNIVERSITY RESEARCH EQUIPMENT ASSISTANCE PROGRAM

THE BEGINNING OF REAP

The Research Equipment Assistance Program (REAP) at Iowa State University (ISU) was developed in the early 1970s because of a suggestion made by an advisory committee studying equipment problems at the university. This committee believed that an equipment sharing and loan program would make it easier for faculty members contemplating projects involving equipment to perform preliminary experiments. Implementation began with the part-time efforts of the late Alfred J. Bureau, then Assistant Professor of Physics, and Roger G. Ditzel, then Assistant to the Vice-President for Research. As a result of initial studies, a project was initiated in September 1972 to gather information on the use and availability of major research equipment at the university.

On February 1, 1974, the National Science Foundation Research Management Improvement Program funded a research proposal on this subject submitted by Iowa State University. The objective of this research was to develop and demonstrate a system for improved utilization of high-value research equipment that would increase research productivity. The functions involved in the research program included (1) information gathering, (2) inquiry processing based on requests representing equipment needs, (3) user education, (4) computer support, and (5) maintenance, replacement, and storage requirement studies.

Through this study, it was determined that any equipment assistance system should provide:

- a means of identifying and locating usable, highly diversified research equipment to allow planned research to be conducted without unnecessary new item purchases;
- information on availability for use by others of equipment items assigned to and used part of the time by one individual or research unit;
- a means of identifying unused equipment so that provision can be made for proper storage and necessary maintenance;
- a capability for knowledgeable decision making relative to disposal of obsolete or high maintenance cost items; and
- a means of retrieving problem-solving types of information, for example, potential spare parts sources on the campus.

A boundary condition on any such system exists and must be recognized in its structuring and implementation. That boundary is one of acceptance by the university researcher. No matter how sophisticated or well planned the system, it cannot succeed without the overt cooperation of the majority of researchers. If researchers perceive it as "taking their equipment away," they will not cooperate.

RESULTS OF THE RESEARCH PROJECT

As a result of the research project, investigators believed it was possible and economically feasible to implement an equipment information and sharing system to improve the productivity of university research personnel. With proper structuring and a low-key, nonthreatening introduction of a system designed to be responsive to needs, it was thought that researchers would cooperate and take advantage of the benefits offered.

When the grant period ended, over 2,500 items of research equipment had been examined and cataloged, acceptance by ISU researchers of the philosophy and mechanics of sharing had been achieved, and four volumes of information on the developed system, plus videotapes and slide shows, were made available to other universities.

RESEARCH COMPLETED; REAP CONTINUES

Because of the successful findings of the research study, the university has continued to support the REAP program since the grant expired. The program is administered by the Office of the Vice-President for Research. By 1974, a central office was established to serve as a communications center and focal point for the program and was staffed by a full-time clerk. This office is purposely located in an education and research building and not in the central administrative building. (It was felt that faculty members might be more comfortable and willing to use the service if it were in their own setting.)

The central office handles all inquiries and information processing. An inquiry is defined as a request to the REAP central office for assistance in relation to equipment. The inquiry may relate to the need for equipment, spare parts, operating manuals, help in definition of equipment needs to carry out a certain task, etc. Inquiries may be satisfied by a loan of equipment from the REAP office to the researcher's department, by a loan from one department to another, by researchers' sharing a piece of equipment in the same location, by finding minor parts, by providing information or manuals, or by referring the inquirer to others who have the same equipment. Since the inception of the program, the rate of inquiries has greatly increased. The tabulation below shows the total inquiries for the 12 years 1973-1984 and includes the number of those inquiries satisfied or not satisfied. It has been found that the high success rate in satisfying inquiries has been a major factor in the positive image the REAP program enjoys.

REAP Inquiries

Calendar Year	Total Number	Number Satisfied	Number Unsatisfied
1973	42	33	9
1974	208	168	40
1975	395	335	60
1976	953	799	154
1977	2,236	1,754	482
1978	2,108	1,672	436
1979	1,924	1,724	200
1980	2,201	2,012	189
1981	2,322	2,175	147
1982	2,173	2,029	144
1983	2,021	1,904	117
1984*	1,445	1,412	33

*Includes nine months of data (January-September).

REAP CATALOG

One of the first goals of REAP was to generate a catalog of existing equipment, with an estimate of the availability of the equipment for loan or transfer. The June 1984 listing contained nearly 10,000 items (each with an initial acquisition cost of $500 or more) having a total value of nearly $30 million. It is estimated that about 90 percent of all research equipment on campus is recorded in the computerized REAP catalog.

RESEARCH TECHNICAL ASSISTANCE GROUP

One function of the program that has proven to be exceptionally successful has been the capability of providing expert repair and calibration of most items of equipment. This has led to the recent development of a separate program known as the Research Technical Assistance Group (RTAG). RTAG complements the repair service of other university shops by offering minor repairs of balances, microscopes, nuclear counting systems, mass spectrometers, gas chromatographs, spectrophotometers, and electron microscopes. A major service is the diagnosing of equipment problems with subsequent referral to other university repair shops.

SUCCESS OF REAP

Perhaps the ultimate testimony to the importance of REAP was provided in 1978 by an "important notice" addressed to the presidents of U.S. universities by Richard C. Atkinson, then Director of NSF. In it he called attention to the Iowa State REAP system and recommended that others follow suit.

The value of REAP and its spin-off, RTAG, to Iowa State University is great. The number of inquiries alone proves that the program is popular and heavily used. In terms of actual dollars saved due to satisfied inquiries, records indicate that the REAP program has saved the university nearly $4 million since it began in 1973. In estimating equipment value as a benefit, the gross value of the item is not used. Instead, the length of time of the loan is taken into account and a "pro rata" value used, in order to arrive at a realistic equipment benefit value. Any equipment on loan for more than 100 days (which includes permanent transfers as well) is assumed to have produced savings equivalent to the full value of the equipment.

The following system is used based on acquisition cost or value of the item:

- three percent per day for a loan span of one to three days,
- ten percent per week for a time span of four days to three weeks,
- thirty percent per month for a time span of three weeks to 3 1/3 months, and
- one hundred percent for loans over 3 1/3 months.

For low-value items, a minimum transaction value of $5 is used. This method for computing savings has been approved by the General Accounting Office in Washington, D.C.

In addition to the savings mentioned above, many dollars are saved by RTAG's ability to make expensive equipment repairs (which sometimes results in the elimination of expensive service contracts).

QUESTIONS

For further information regarding the REAP program at Iowa State University, please contact Wayne Stensland, Manager, REAP, 103 Physics, Iowa State University, Ames, IA 50011 (telephone: 515/294-5536).

SOURCE: Vice-President for Research, Iowa State University (October 1984).

APPENDIX H: EXAMPLES OF DEBT FINANCING

EXAMPLE 1: REVENUE BOND ISSUE BY STATE UNIVERSITY

Description

Revenue bonds were issued by a state university to finance:

- refunding of existing notes,
- construction of new facilities at the university hospital,
- debt service reserve of the new issue, equaling the maximum annual debt service,
- construction period interest, and
- expenses incurred for bond issuance.

The bonds represent a limited obligation of the university regents and are secured by the gross revenues of the hospital. The bonds do not represent a debt obligation of the state.

Decision Factors

There are three main reasons why the university issued long-term debt.

1. The university hospital's funding requirement was substantial. The revenue bonds allowed the institution to minimize its borrowing cost, raise the necessary capital, and provide a debt repayment schedule that could be met out of hospital revenues.
2. The project was long term and included the construction of new buildings. The bonds allow the institution to match the life of the asset to the period over which the debt will be repaid.
3. During the past decade, the issuance of revenue bonds has become the primary source of capital for construction projects and major equipment purchases.

Terms

Amount of Issue:	$110,000,000.
Period:	The total issue was for 30 years. However, the individual bonds have maturities scheduled annually over the 30 years. The university also has the option to buy back the bonds from the investors before the maturity date (i.e., early redemption of bond).
Interest Rate:	Varies by bond dependent upon the date of maturity. The interest rate ranges from 6.5 percent to 9.875 percent. The interest rate on the bond is referred to as the coupon rate.
Additional Fees:	The issuance cost of the bonds totaled $3.5 million, which included financing and related costs and original issue discount.
Security Required by Lender:	A portion of the bond proceeds was set aside to establish a debt service reserve fund.
Terms Required by Borrower:	The bond represents a limited obligation of the university and is secured by the hospital's revenue.
Type of Project:	Ambulatory care facility.

Features

Obligation

The bonds are secured by the financial resources of the hospital. The hospital is required to maintain certain financial operating ratios, which would ensure that there are sufficient funds to meet the bond debt service. The rate covenant states,

> The hospital's annual net revenues (gross revenues minus expenses) are at least 125 percent of the annual debt service payments (interest plus principal).

If this ratio is not maintained, the university regents are responsible for taking corrective action. The bonds will be serviced by the revenues generated by the institution and the debt service reserve fund.

Security

The bonds are secured by the debt service reserve fund, which is established at the time the bonds are sold. The reserve contains sufficient funds to cover the maximum possible annual debt service.

Preparation of Official Statement

The revenue bond statement presents detailed financial information on the university and the hospital to demonstrate the source of revenues to potential investors.

Additionally, a detailed financial feasibility study was prepared for the construction project. These studies are used both to demonstrate financial soundness to investors and, when necessary, to provide required data for the State Certificate of Need process, through which state health planning agencies control the expansion of health care facilities. In this study, the investor was shown:

- assessment of the need for hospital services in the area,
- review of economic factors that would affect the success of hospital operations,
- review of forecasts for the hospital's utilization rates for services, and
- review of the financial forecasts, including the factors influencing revenue and cost estimates.

EXAMPLE 2: REVENUE BOND POOL

Description

Revenue notes were issued by a state educational authority to finance equipment purchases and rehabilitation projects for 15 private colleges within the state. The notes are limited obligations of the authority, payable only out of revenues and pledged funds of the participating private institutions. The revenues consist primarily of the loan repayments made by the colleges according to their debt repayment schedule as stated in their individual loan agreements with the authority.

Decision Factor

Fifteen institutions participated in the program.

The individual institutions' loans ranged from $17,745,000 to $120,000 for a period of two to seven years. One institution, a large private university, had the largest loan amount of $17.7 million for equipment acquisition and construction over a five- to seven-year period. Participation in the pool provided both large and small institutions access to tax-exempt debt. Generally, only large institutions would be able to issue their own bonds because of their established credit ratings.

Terms

Amount of Issue:	Total issue was approximately $50 million.
Period:	The issue has maturities scheduled over two- to seven-year periods as stated on the individual bonds.
Interest Rate:	Varies by bond dependent upon the date of maturity. The interest rate ranges from 6.25 percent to 8.75 percent. The interest rate on the bond is referred to as the coupon rate.
Additional Fees:	The issuance cost of the bonds totaled $2 million, including basic issuance cost, insurance premium, and underwriters' discount.
Security Required by Lender:	$5 million of the bond proceeds were set aside to establish a debt service reserve.
Terms Required by Borrower:	The participating institutions enter into an individual loan agreement with the educational foundation authority.
Type of Equipment:	Computers and other equipment for research, telecommunications, and energy conservation; and building renovations.

Features

Administration

Each college or university enters into a separate loan agreement with the authority. These loan agreements are based on the useful life of the college's equipment purchase and the college's credit worthiness. The college is required to make semiannual debt service payments to the authority, reflecting principal and interest payments, insurance premium amortization, issuance cost amortization, administrative cost, investment earnings shortfall, and any other authority-required payment.

Credit Requirements

The participating colleges entered into three types of loan agreements: (1) an unsecured general obligation to make debt service payments; (2) a general obligation to make debt service payments secured by real or personal property of the college; and (3) a general obligation to make debt service payments secured by real or personal property of the college, as well as a bank letter of credit.

In this issue, the pool includes both colleges with strong credit ratings and those without any proven credit experience. The three types of loan agreements provide for the necessary credit enhancements to obtain a favorable credit rating for the issue without penalizing the financially stronger colleges with a higher interest rate than these larger institutions would normally obtain on an individual bond.

Evaluation Criteria

The authority and the insurer of the issue reviewed the individual college's financial condition to determine eligibility in the program. The colleges were required to maintain a minimum two-to-one available assets to general liabilities ratio for the latest fiscal year, as well as to generate positive unrestricted current fund earnings after expenditures and mandatory transfers. Additionally, nonfinancial indicators were reviewed, such as enrollment data and trends.

Special Considerations

The insurer has committed to the issue an insurance policy that will insure the payment of principal of and interest on the bond. In the event there are not sufficient amounts available in the debt service fund and the debt service reserve fund to make debt service payments, the authority's trustee notifies the insurer of the deficient amount, and the insurer is obligated to pay the deficient amount according to the terms of the insurance policy.

EXAMPLE 3: INDUSTRIAL DEVELOPMENT BOND

Description

The industrial development bonds were issued by two county development authorities to provide funds to the research foundation for the construction of and equipment for a scientific and technical research facility and the purchase of an existing research facility from a private corporation. The research foundation, a state nonprofit corporation, has entered into a loan agreement with each issuer, in which the issuers loan the bond proceeds to the foundation for the research facility projects. The loan agreements require the foundation to pay the principal, premium (if any), and interest on the bonds, together with all associated costs and expenses. The foundation will lease the facilities to an affiliated research corporation of the state university and to a private corporation. The lease to the private corporation is incidental to the transaction with only a small portion leased back to the corporation selling the facility as a condition of the sale. These lease payments will be the revenue source for the debt repayment. The university has planned to fund its lease payments (i.e., bond retirement) entirely through indirect cost recovery.

Decision Factor

The university had considered raising the funds through a state building authority. However, the construction costs would have been $25 per square foot higher under the state authority than with the industrial development bonds. Additionally, the state building authority's financing process is oriented to academic rather than research projects; it is cumbersome and slow, with numerous regulations. In issuing the industrial development bonds, there is some risk if the federal government contests the arms' length relationship between the university and the foundation. However, in the instant case, the arm's length relationship has been recognized by the government.

Terms

Amount of Two Issues:	Approximately $17.2 million and $7.3 million.
Period:	The larger issue has maturities scheduled over 1- to 20-year periods as stated on the individual bonds. The smaller issue has maturities varying over 10 years.
Interest Rate:	Varies by bond dependent upon the date of maturity. The interest rate ranges from 5.5 percent to 9.625 percent. The interest rate on the bond is referred to as the coupon rate. Additionally, 1.25 percent of the amount of 103 percent of outstanding bonds is payable annually as a letter of credit fee.
Additional Fees:	The issuance cost of the bonds totaled $696,000, including financing, legal, printing, and miscellaneous expenses. Legal fees alone were $90,000. The first year's letter of credit fee was $340,000.
Security Required by Lender:	As part of the debt service requirements, a sinking fund will be started in year 13 for bonds maturing in year 20. (Note: A sinking fund represents an accumulation of funds by the issuer over a period of time to be used for retirement of debt, either periodically or at one time.) The letter of credit bank required security interests in the assets of the projects.
Terms Required by Borrower:	Though two counties issued the industrial development bond, the bonds are to be repaid by the foundation.
Type of Project:	The smaller issue was used by the foundation to purchase and renovate an existing research complex consisting of 50+ acres of land and 130,000 square

feet of office and laboratory space. The larger issue was used to purchase land and to design and construct a six-story 190,000 square foot laboratory building adjacent to the campus.

Features

Obligation

The bond investors will look to the letter of credit bank, which will look to the foundation for repayment. The bonds are a limited obligation of the issuing authorities and do not represent any indebtedness of the state.

Security

The primary security for the issue is the letters of credit and confirming letters of credit. In the event the foundation defaults on its loan agreement, the bond trustee will draw the necessary funds from the letter of credit bank to buy all bonds from the bond holders. If the letter of credit bank dishonors its obligation, the bond trustee will draw upon the confirming letter of credit bank to make payment. This arrangement allowed a Standard & Poor's AAA rating, though the foundation was essentially without assets. The letter of credit banks are secured by security interests in the research facility's land, buildings, and equipment. The foundation has assigned the facility's rents and leases. The university's affiliated research corporation is obligated to pay one year's debt service to the letter of credit bank in the event of foundation default and agrees to maintain its net worth at least at that level.

Administration

The foundation was formed for the purpose of supporting research activities of public and nonprofit colleges and universities in the state. It is considered a charitable, educational, and scientific organization exempt from federal income taxes. The foundation has no plans to undertake any fundraising and expects to rely upon rent charges from the research institute for the use of the facilities. The foundation has no long-term lease or contractual commitments from the research institute and its affiliated university.

EXAMPLE 4: STATE UNIVERSITY LINE OF CREDIT

Description

The university established a standby line of credit with a state commercial bank for the purpose of purchasing self-liquidating equipment. The line of credit is drawn upon by department heads or principal investigators on an as-needed, project-by-project basis. Their requests for funds are presented in loan agreements that specify the use of funds, the period of need, and the revenue source for repayment. Once these requests are reviewed, the funds are drawn from the line of credit within funding limits set by the Board of Regents and the lending limit agreed to by the bank.

Decision Factor

The university had experienced difficulty in finding adequate funding for equipment related to instructional and research activity. Funds from general operating budgets had been largely used for instructional equipment needs and had not adequately met the needs of the research programs. The university has found that its faculty's ability to continue a high level of externally sponsored research is dependent on its ability to obtain state-of-the-art equipment. With the recent changes in OMB Circular A-21 which allow the university to be reimbursed for interest on equipment purchases over $10,000, the university decided to obtain a line of credit, which could be used to acquire self-liquidating equipment over $50,000. Equipment financed through the line of credit in connection with external grant or contract arrangements would qualify as self-liquidating because both principal and interest on borrowed funds would be fully recovered from the grant or contract over the financing term.

Since establishing the equipment financing plan, the university has encountered some difficulty in receiving specific grant approval from at least one agency for the reimbursement of financing cost. When the line of credit plan was being considered, a description of the plan was sent to and discussed with Department of Health and Human Services, National Institutes of Health, National Science Foundation, Office of Naval Research, and the National Aeronautics and Space Administration. All agreed that the plan was appropriate and conformed to A-21 guidelines.

The line of credit has only been used to acquire equipment for one grant. The cost of the equipment will be covered by the grant funds. However, the interest costs are being paid out of a private gift fund because the sponsoring agency denied the request for reimbursement of interest cost.

Terms

Amount of Issue:	The ceiling for the line of credit was negotiated at $2 million.
Period:	The line of credit was negotiated for a five-year period with options to renew. Either the bank or university can terminate the contract at any time except with respect to outstanding loans.
Interest Rate:	Stated at about two-thirds of the bank's prime interest rate.
Additional Fees:	None.
Security Required by Lender:	None.
Terms Required by Borrower:	The bank will make loans to the university on a project basis with actual lending occurring only if the grant is awarded or if user fee terms are agreed upon to cover debt service.
Type of Project:	Various scientific instruments.

Features

Agreement

The university's Board of Regents approved the line of credit agreement after a competitive bid process in which a number of bank proposals were reviewed. The terms of the agreement specified:

- the ceiling of the line of credit,
- a commitment for lending on a project basis rather than in a lump sum,
- interest on a tax-exempt basis,
- interest rate established as an index to the bank's prime interest rate, with the rate for each individual loan set at the time a draw on the line of credit is negotiated, and

- that the agreement can be terminated at any time by either party except with respect to outstanding loans.

University Procedures

The principal investigator or department head seeking external funds for research equipment over a prescribed amount prepares a request for funds to the vice-president for educational development and research. This request presents a justification for the need and the funding requirements. The request has to describe the method for repayment as follows:

1. Existing grants that have a multiple year funding period could be rebudgeted. This could represent one or more principal investigators.
2. Equipment financing could be proposed in a grant application.
3. User charges and fees could be from external and/or internal users.

The request will be reviewed, and the cost analysis performed to determine the financial resources required to liquidate the debt. Approved requests are forwarded to the university business officer who maintains the banking relationships with the line of credit bank. The business officer will contact the bank to determine the terms of the new loan. If the terms, interest rate, index, and maturity are favorable, the business officer will request the bank to commit the funds to the new loan.

Once the loan is executed and funds transferred to the university, a loan account is established in the university plant fund. The equipment is purchased from this account. To provide an audit trail for liquidation of the debt, plant fund expenditures will be reimbursed through charges to the grant account in the current restricted fund or through transfers of depreciation amounts from the service account. The Board of Regents is to receive a monthly status report on the loans made from the line of credit. Additionally, the Board of Regents is to be notified when the line of credit ceiling has been reached.

EXAMPLE 5: ACQUIRING BIOMEDICAL EQUIPMENT

Description

The university obtained a demand note for a variety of funding requirements, including both instructional uses and research

Terms Required by Borrower:	None.
Type of Project:	State-of-the-art equipment for the radiology department costing $1.4 million.

Features

The radiology department had an immediate need for the equipment but had insufficient funds to purchase the item. Access to the demand note proceeds enabled the department to acquire the equipment and pay for it later.

The demand note is serving as an intermediate financing instrument. The radiology department pays only the interest on the loan, and the hospital will repay the loan principal in two years from its capital outlay budget. In two years, the hospital will be able to justify the use of the equipment in patient care. Until that time, the department will cover the line of credit interest cost through user charges.

At the time the equipment is transferred from experimental to clinical use, it may be necessary to apply to the state health planning agency for a Certificate of Need under health planning statutes. The procedures vary from state to state and also over time, so that the precise requirements will not be known until the time for transfer.

EXAMPLE 6: MUNICIPAL LEASE

Description

Telecommunications equipment was acquired for a state university through its affiliated foundation. In this municipal lease, the university was the lessee and a bank was the lessor. The title to the equipment passed to the university at the end of the lease term.

Decision Factor

The municipal lease was used by the university to finance equipment acquisition because the state restricted the university from entering into multiyear indebtedness. The university was able to acquire the equipment with the municipal lease because the lease is renewed each fiscal year. The cost of the lease can needs. The specific demand note was obtained after a competitive bid process in which proposals from a number of lending institutions were reviewed.

The demand note was used to finance the acquisition of a specialized piece of equipment for the radiology department of the medical school. The department needed to acquire the equipment immediately for research, but the hospital would not be able to use it for patient care, as third-party payers, specifically Blue Cross, considered its use experimental.

Decision Factor

The university decided to obtain a demand note to acquire equipment that the university had normally leased. The note provided a cheaper form of financing than leasing. However, the university still leases small pieces of equipment such as copiers. When the university was first considering the demand note, there were several projects, academic as well as research, that needed temporary or short-term funding. The university had a general set of guidelines for selecting the projects to fund with the demand note proceeds. All funds had to be used within six months because of arbitrage restrictions.

Since the time the demand note was obtained, several projects have repaid their debt or replaced the debt with long-term financing. Other projects have been substituted as funds are replaced.

Terms

Amount of Issue:	$15 million.
Period:	Five-year period with cancellation clauses.
Interest Rate:	Stated at about one-half of prime interest rate.
Additional Fees:	The university obtained a backup line of credit that cost an additional 1/2 percent.
Security Required by Lender:	The lender was a mutual fund. The university pledged its unrestricted endowment funds as collateral.

also be passed on to federal grants and contracts for which the equipment is used.

Terms

Amount of Issue:	$500,000.
Period:	Municipal lease is written on a yearly basis with annual renewal options. The effective length of the lease, including renewal options, is six years. At the end of this time, the university will receive title to the equipment.
Interest Rate:	Less than 10 percent.
Additional Fees:	Administrative fee to the foundation calculated as a percent of the principal amount of the lease.
Security Required by Lender:	Security interest in the purchased equipment.
Terms Required by Borrower:	The university had the option to cancel the lease on a year-to-year basis in the event that funds were not appropriated for the lease.
Type of Project:	Telecommunications equipment.

Features

The foundation handles the administrative and control procedures for arranging the municipal lease. In this case, the university Atmospheric Science Department had need for telecommunications equipment. This need was documented and reviewed.

The municipal lease was open for bid, and the proposal with the most favorable terms was accepted. Because of state requirements, the finalization of the municipal lease agreement requires a lengthy approval process. A municipal lease transaction may require a tax-exempt opinion from legal counsel if the lessor requests one.

In the department's lease request, the equipment acquisition has to be justified. The department also has to explain the source and frequency of revenue to repay the debt and has to incur the cost of equipment insurance.

The department is responsible for funding the debt. It should be noted that the university in this case cannot borrow except for self-sustaining enterprises.

EXAMPLE 7: ADJUSTABLE RATE OPTION BOND

Description

The revenue bonds were issued by a state educational authority to fund a facilities project at a private university, including:

- construction of the university computing center,
- purchase of existing land and buildings for use as research, education, and student activities facilities,
- renovation and construction of laboratory facilities for the biology and chemistry departments,
- acquisition of equipment for the computing center,
- acquisition of apartment buildings for student housing, and
- construction and renovation of civil and chemical engineering laboratories.

The university will initially lease to the authority the various existing facilities referred to under project facilities. In turn, the university will sublease the facilities back from the authority and use the bond proceeds to complete renovation and construction of these facilities. The bonds will be payable solely from the university's sublease payments to the authority. The bonds are limited obligations of the authority. The bonds are not a liability of the state or any political subdivision of the state.

Decision Factors

The major reason that the university issued an adjustable rate bond (ARB) was the low interest rates in the short-term market versus the long-term fixed rate debt market. In the first year, the ARB had 6 1/4 percent interest. If the university had issued a long-term fixed rate debt instrument, the interest rate would have been 10 percent. The savings in first-year interest were significant. Though the bond's interest rate will be adjusted annually, the university has the option to convert to a fixed rate if long-term interest rates become favorable. Many institutions are using ARBs because of the favorable market conditions, including low short-term interest rate as compared to long-term rates and quick placement of bonds with investors.

Terms

Amount of issue:	$35,000,000.
Period:	The total issue was for 20 years. However, the bond holders have the right to tender (i.e., to have their bonds repurchased by the university) at a price equal to 100 percent of the principal amount on the annual anniversary of the issue date. The university has the option to redeem the bonds (i.e., to buy back the bonds from the bond holders) after one year from the date of issue. There are also optional redemption provisions that the university may exercise. Additionally, if the bonds are converted to a fixed interest rate, the bond holders will no longer have the right to tender their bonds.
Interest Rate:	The interest rate at the date of issue was 6 1/4 percent. Annually, on the anniversary of the issue date the interest rate will be adjusted to reflect changes in the interest rate index. The indexing agent of the issue will be responsible for determining the adjusted interest rate on an annual basis, according to an average yield of at least 20 twelve-month tax-exempt securities with a comparable debt category and rating of the university's bond.
Additional Fees:	The issuance cost of the bonds totaled more than $500,000.
Security Required by Lender:	Under the indenture agreement, the university is required to maintain cash and securities with a trustee to pay principal and interest to bond holders in the event that sublease revenues are insufficient to cover debt service. Initially, the university pledged to maintain unrestricted assets in the amount of $37 million, which will be reduced as bonds are retired.

Terms Required by Borrower:	The university has the right to convert the bonds from an adjustable interest rate to fixed interest rate. Prior to the conversion to a fixed interest rate, the bond holders have the right to tender (i.e., return) their bonds for purchase by the university.
Type of Project:	Various research and institutional facilities as described above.

Features

Administration

The authority will issue the bonds and place the bond proceeds with the trustee for distribution to the university. Under a sublease agreement with the authority, the university will receive the bond proceeds for construction and renovation of project facilities. In turn, the university's sublease payments to the authority will cover the principal, premium (if any), and interest payments. The university would be required to fund any tendered bonds if the returned bonds could not be remarketed and replenish the debt service reserve fund if the reserve is reduced. In the event that a bond holder tenders his bond to the university, the remarketing agent will try to the best of its ability to resell the tendered bonds.

Adjustable Interest Rate

The interest rate on the bonds will be adjusted on an annual basis based on the index defined above under interest rate in the section on terms. The rate will be determined by the remarketing agent to be the rate that equals but does not exceed the interest rate necessary to sell all of the bonds tendered.

Conversion to a Fixed Interest Rate

At the direction of the university, the bonds may be converted to a fixed interest rate, which would hold constant until the date of maturity. The university could convert the bonds to a fixed rate if interest rates were anticipated to increase. The bond holders would have the right to tender (i.e., return) their bonds to the university prior to the bonds' being converted to a fixed interest rate.

Security

The unique feature of this ARB is that it was done without a backup letter of credit. Normally, a bank letter of credit would cost annually 1/2 percent to 1 percent of the principal balance. The university was able to receive an AA rating and sell the issue because it pledged to maintain unrestricted assets at $37 million. Therefore, the university reduced its net interest cost as compared to similar issues.

SOURCE: Coopers & Lybrand.

APPENDIX I: DEBT FINANCING INSTRUMENTS

Applicable Institution	Financing Range	Term	General Description
Leasing			
Private college or tax-exempt foundation	$100,000 to $1,000,00	Short-term 1-10 years	Leasing is considered a long-term rental agreement in the form of operating lease or capital lease.
Municipal Leases			
State	$100,000 to $1,000,000	1 year	A municipal lease is considered a conditional sale lease where the payments are scheduled like a lease but the lessee is considered the property owner at the lease inception. The lessor receives tax-exempt status on the interest portion of the lease payment. This form of debt is used when the entity (state, municipality, or state university) is precluded by state law from entering into debt for a longer period than a single fiscal year.

Advantages	Disadvantages
Institution acquires the use of equipment without making a substantial initial cash outlay.	If the institution has substantial capital needs and can issue debt, long-term financing would be more cost effective than leasing.
Leasing provides a means for financing small equipment acquisitions.	
Lessee has some protection against equipment obsolescence.	Leasing requires trade-offs to be made on whether the institution acquires title to the equipment.
Off the balance sheet debt.	
Quick and easy form of financing.	Leasing is another form of debt which will have an impact on the institution's cash flow.
Short-term financing with annual renewal options allowing for long-term financing as needed.	Lessors consider municipal leases risky because the government is legally committed only for a single fiscal year. The lessor will charge more to cover the risk of cancellation.
Leasing provides some protection against technical obsolescence of the equipment.	

Applicable Institution	Financing Range	Financing Term	General Description
Line of Credit			
State or private university or foundation	$1-15 million	1 to 5 years	Represents an assurance by a lending institution that funds will be made available as specific project needs arise. A university establishes a line of credit agreement with a bank, defining the terms, conditions, and interest rate to be required before an actual loan is made. The agreement states the aggregate ceiling of the loans to be outstanding at any one time.
Pool Revenue Bonds			
State or private institution	Minimum $5 million	10 years	Offers tax-exempt bond financing to a group of colleges and universities to finance numerous small projects. Two types of bond pools: blind pools do not identify the individual borrowers or the projects; composite pools identify all participants and projects and loan amounts to be included in bond issue.

Advantages	Disadvantages
Insurance of funds availability against likely but uncertain needs.	Administrative cost and time required to review loan request and monitor debt repayment.
Ability to debt finance low-priced equipment on more favorable terms than leasing.	Risk that the debt repayment guarantees of dept. heads and principal investigators will not be honored.
Ready access to funds so that equipment procurement is not delayed until grant or contract funds arrive.	
Availability of funds until permanent debt financing can be secured.	
Insurance of funds availability if unexpected needs develop.	
Institutions are able to pool their capital needs when institutions have insufficient capital needs to make an individual	Pool Revenue Bonds have the same disadvantages as revenue bonds.

Applicable Institution	Financing		General Description
	Range	Term	
Pool Revenue Bonds (continued)			
			The bonds are issued by a state educational authority, which disburses the bond proceeds to participating colleges and universities. While the authority holds the bond proceeds until the institutions need funds, the authority may invest the funds at a higher interest rate than the bond interest rate. The net interest income earned on available funds is used to partially cover administrative cost. The IRS requires that all bond proceeds be disbursed to pool participants within three years.
			The period of the institutions' loans range from three to ten years but cannot exceed the term of the bond issue.
			The financial liability of the participating institutions is limited to the amount of their individual loan agreements.

Advantages	Disadvantages
revenue bond cost effective or an institution does not have a credit rating to issue debt on its own.	If sizable debt reserves and insurance premiums are required to protect against the risk of loan defaults, the more creditworthy institutions in the pool may be subsidizing the cost of debt for the less creditworthy institutions. The financially stronger institutions may be able to obtain lower interest rates through individual bond issues and may not wish to participate in the pool.
Allows smaller institution access to tax-exempt debt financing.	
Spreads the cost of issuance among a number of institutions.	

Applicable Institution	Financing Range	Financing Term	General Description
Pool Revenue Bonds (continued)			
			The individual institution's interest rate may vary per loan agreement with the authority to properly reflect differences in loan risk between a financially strong institution and a small college.
Tax-Exempt Variable Rate Demand Bond (VRDB)			
State or private university with the assistance of government authority	Minimum $3 million	Nominal maturities of 25-30 years	Bond carrying a floating interest rate which is set periodically to a percentage of prime interest rate or treasury bills. The bond is priced as a short-term security with a nominal long-term maturity.

Advantages	Disadvantages
Provides the university access to lower interest rate debt instruments. Raise substantial funds for major projects when long-term rates are too high to issue permanent financing.	Risk and cost associated with the constant change and movement in the short-term debt market (i.e., if a bond is returned and cannot be immediately resold to a new investor, the university will have to draw on its letter of credit to repay the bond holder). Risk that the university may not be able to roll over the VRDBs into long-term debt.

Applicable Institution	Financing		General Description
	Range	Term	
Tax-Exempt Commercial Paper (TECP)			
State university or private college or foundation	Pool program minimum $50 million	TECP-270 days or less Pool program 10 years	TECP are short-term obligations with stated maturities of 270 days or less, comparable to corporate commercial paper except interest rate is tax-exempt.
	Individual loans minimum $100,000	Individual loans 1-10 years	A pool program can be established by a designated government authority which issues the TECP and lends the funds to participating institutions. The TECP is designed to be rolled over at its maturity without delays and additional issuance cost. The interest rates on the participating institutions' loans are determined monthly, based on the average interest rates of the TECPs sold in a month.
General Obligation			
State university	Minimum $3 million	20-30 years	Long-term bond secured by the full faith, credit and, usually, taxing power of the state or local government.

Advantages	Disadvantages
A university has access to short-term debt at favorable interest rates.	For major, long-term project to fund, a Revenue Bond or another long-term debt instrument would match the useful life of the asset.
Issuance costs are shared by all participants.	
Because the TECP has a short-term maturity and is continually rolled over, the university is not locked into long-term debt and can repay anytime without penalty.	For less cost a university with an established credit rating may be able to access short-term financing through a line of credit.
Favorable credit ratings can be obtained for the issue because it is backed by the state or local government.	Legislative approval is required for the bond. If approval is delayed, project would have to be delayed or postponed.

Applicable Institution	Financing		General Description
	Range	Term	
Revenue Bonds			
State university or private university or college or tax-exempt foundation	Minimum $3 million	20-30 years	Long-term bonds issued to finance a specific revenue-generating project. The bonds are secured either by the project's revenue or the revenue of the institution as a whole. For a private institution to use revenue bond financing, the institution must obtain the assistance of a county, industrial development authority, educational facilities authority, or similar agency. The bond investor will look at the institution's overall revenue-generating capability as a means of assessing its ability to meet interest obligations and principal payments. State requirements vary on the authority state universities have in issuing revenue bonds.

Advantages	Disadvantages
Revenue bonds are cheaper than any form of commercial financing because interest to revenue bond investors is exempt from federal taxes.	The high issuance, legal, and brokerage fees associated with bonds mean that a substantial dollar amount is necessary to make the bond cost effective.
	The Revenue Bonds are direct obligations of a state university or college with the bond holders' looking to the university (not the state) for repayment of principal and interest.
	The attractiveness of revenue bonds is influenced by the investor's need to protect from taxes. With any lowering of tax rates, the investor will have less need to shelter income through revenue bonds.

Applicable Institution	Financing		General Description
	Range	Term	
Industrial Development Bonds			
Private college or university or tax-exempt foundation	Minimum $1 million	20-30 years	A security issued by state, local government, designated agency, or development corporation to finance the construction or purchase of buildings and/or equipment to be leased to a private corporation (institution). The credit of the private institution is considered to be the credit backing the issue.

Advantages	Disadvantages
	As that happens, to keep attracting investors, institutions will have to offer revenue bonds with higher interest rates, which will increase the institution's borrowing cost.
	Revenue bonds are long term in nature and not appropriate for financing short-term equipment needs.
Industrial Development Bonds provide private institutions a means of raising substantial capital.	The Industrial Development Bonds have the same disadvantages as revenue bonds.
Industrial Development Bond interest is also exempt from federal taxes.	

Applicable Institution	Financing Range	 Term	General Description
Certificates of Participation			
State or private universities	Minimum $1 million	Life of asset	Certificates of Participation are similar to On Behalf of... leases except there is no third-party guarantee. The purchaser of the certificates has an interest in the equipment lease. The certificates represent a lien on the asset.
On Behalf of...			
Tax-exempt foundation	Minimum $1 million	Life of asset	Third-party guaranteed revenue bonds or leases issued by a foundation on behalf of a state or private institution. Title to equipment is held by the foundation and passes to the institution when the debt is retired.

Advantages	Disadvantages
Institutions that do not have tax-exempt foundations can issue the certificates. Institutions are able to finance large dollar value equipment through public securities investors at longer terms and at lower interest rates than other debt instruments require.	Institutions will have to plan for the annual funding of the certificates as a fixed obligation. The purchaser will look to the institution's revenue-generating capability to meet this fixed obligation and assess his risk position.
Debt does not affect the university or college's balance sheet. Lease would be on a year-to-year basis with annual renewal. State institutions which need legislative approval for Revenue Bonds can use On Behalf of... financing without state government approval. The foundation funds and enters into the long-term lease.	On Behalf of... financing is viewed as an indirect obligation of the institution. Investors will look to the institution's revenue-generating capability to assess the risk of the issue.

SOURCE: Coopers & Lybrand.

APPENDIX J: EXAMPLES OF EQUIPMENT DONATIONS

Examples 1 through 11 below describe equipment donations involving 14 universities and 12 corporations. Equipment donated includes computed axial tomography scanners, digital fluoroscopes, nuclear magnetic resonance spectrometers, mainframe computers, microcomputers, software, oscilloscopes, spectrometers, laser units, processing equipment for very large-scale integrated circuitry, computer-aided design systems, and semiconductor manufacturing equipment.

EXAMPLE 1

Circumstances of Donation

- Principal investigators contacted research colleagues at the corporation.
- The university faculty had produced innovative ideas; these were then licensed to the donor and developed into successful products.
- The university was viewed as a recruiting source.
- The university would be used to market the donor's equipment; principal investigators would be requested to show equipment to potential purchasers; results of equipment usage would be provided for trade and scientific shows.

Special Considerations

- The donor receives license for any marketable research; the university receives the copyright. The donor must sublicense upon request; both share the royalties from sublicenses.
- The donor expects the marketing activities to be performed.
- In order to have time to obtain patents, the donor has occasionally requested that scientific results be withheld from publication. Although university guidelines provide that publication can only be withheld for 90 days, the university often complies with the request.

Institution's View

- The donation of equipment was seen as the only feasible alternative, since the level of funding necessary for such specialized machinery is unavailable through the National Institutes of Health.
- The equipment is generally high level, although not top-of-the-line.
- The donor has paid all maintenance costs.
- Students have developed the necessary software. The donor has provided an on-site programmer.
- The donor's equipment has been compatible with other equipment. Major items were self-contained.
- The equipment has worked well.
- The researchers feel that the promotional activity is an imposition.
- Patent-related issues have been problematic.

Corporate View

The donor has been happy with the university's work.

EXAMPLE 2

Circumstances of Donation

- University faculty and corporate counterparts had professional contacts prior to the donation.
- The university has an active research faculty that has pursued innovations.
- The university is attractive to corporations because of its accomplishments and innovative ideas.
- Corporations are interested in recruiting university students.
- Tax incentives have made contributions even more attractive.

Special Considerations

- A license to patentable inventions may be made available to the donor.
- There are no restrictions on the publication rights of work undertaken by the university.

Institution's View

The donor does not cover all costs. Researchers believe that they are more motivated to use the equipment if there is some cost to them. Maintenance costs, however, are quite high.

Corporate View

The university is very attractive because of its faculty, programs, and record of success.

EXAMPLE 3

Corporation View 1

- Relationships were established among university development office, department heads, researchers, and corporate counterparts.
- The university identified the equipment that was already available, plans for using the equipment, the potential users of the equipment, and their areas of interest.

Corporation View 2

- The corporation had announced its intention to assist university programs similar to that at the university; there was no previous relationship with the university.
- The corporation's program was focused on a specific area of engineering; the university had one of the country's first engineering schools in this field.

General Corporate View

- Donors were interested in exposing future users to state-of-the-art equipment.
- The tax benefits have not been a primary incentive to small companies.
- Excess inventory resulting from lower sales has been a minor factor.

Special Considerations

No special considerations were identified.

Institution's View

State-of-the-art equipment is now available, although maintenance and technical support costs are a problem. For this reason, not all equipment that is offered is accepted.

EXAMPLE 4

Circumstances of Donations

- For research and development purposes, faculty members and department heads work through corporate contacts to obtain contracts.
- The university has had limited success with sending letters to organizations with no prior contact. Often, the corporation may like something about the program being undertaken, and this will provide a floor for establishing a relationship.
- With scientific equipment, personal contacts are very important. The foundation and development officers will help faculty members and department heads develop plans to inform corporate representatives about proposed projects.
- Scientific equipment is almost never given in isolation. Generally, the university has developed a program that the donor is interested in, and the donor will provide the equipment and money.

Special Considerations

- Scientific equipment never has any quid pro quo.
- With research and development equipment, the nonexclusive use of patents is provided to the contracting corporation, and the university holds the patent. Sometimes the university will receive royalties, depending upon the arrangement.

Institution's View

- Since the donor does not cover all costs, maintenance and operating costs are a major problem.

- The university generally has been happy with the arrangements.

Corporate View

The donating organization appears to be pleased with the way the arrangements have worked out.

EXAMPLE 5

Circumstances of Donation

- The university has a good reputation in many scientific areas.
- The donors receive feedback on prototype equipment to work out bugs.
- The university has productive relations with contributors, which leads to many coming back repeatedly.
- The university faculty conceives interesting projects and establishes personal contacts with donors.
- Tax benefits are helpful but are not a major factor.

Special Considerations

- Certain corporations give many micros to faculty, and there is an agreement to share any software developed. The university has the copyright, but the donor often has exclusive license.
- The donor expects feedback on prototypes.
- There are sometimes restrictions on publication for up to one year, which must be complied with (does not normally cause problems).

Institution's View

- The university is generally happy.
- Often the maintenance costs are covered by the donor.
- Many corporations come back many times.
- Sometimes they are offered more equipment than they can take. They only accept it when it is well matched to their needs.
- They get a good deal of state-of-the-art equipment and prototypes.

Corporate View

There was no specific feedback, but the university assumes they are satisfied since they keep returning.

EXAMPLE 6

Circumstances of Donations

Corporate

- Corporations are interested in exposing future users to state-of-the-art equipment.
- Corporations seek researchers' feedback in order to improve equipment.
- Corporations donate equipment to demonstrate general support for higher education.

University

- The university strictly enforces the conditions under which it will accept gifts: exclusive licensing arrangements are never provided; nonexclusive agreements are acceptable.
- The university will not provide the donor with written feedback; however, oral discussions are acceptable.

Special Considerations

- Donor corporations often contribute ancillary expenses such as maintenance and software along with the equipment.
- Both the university and the corporations initiate contacts. Corporate contacts are developed through visiting committees and other visits by corporate executives and researchers. Individual faculty members develop relationships with corporate counterparts.

Institution's View

Generally, the university has been able to obtain whatever equipment has been needed.

EXAMPLE 7

Circumstances of Arrangements

- Money is primarily given under research contracts. Equipment is supplied if it is needed.
- Contacts are often made through established relationships with universities.
- One university is a popular donee since many alumni work at the corporation.
- Arrangements are often entered into when an institution has begun working on a program in which the corporation is interested.
- Tax benefits have a significant impact on the level of contributions.
- The corporation feels an obligation to help fund university research since more is needed. It cannot fund the amounts it would like to because of the costs. Additional tax benefits would be a desirable way of lowering costs.

Special Considerations

The corporation installs the equipment and for awhile maintains it and provides backup support.

Institution's View

It appears that colleges are satisfied with the arrangements.

Corporate View

Results have been good so far. If they had not been, the corporation would not continue contract research and scientific equipment donations.

EXAMPLE 8

Circumstances of Donation

- The corporation ordinarily makes a grant after a written proposal is submitted; proposals come about as a result of continuing dialogue with university researchers.

- Considerations include the corporation's desire to support education; the quality of the institution, its faculty, and its students; its ability to undertake proposed projects; its fiduciary capability; and the importance to the corporation of the technology under study.
- Ordinarily, R&D expenditures are joint study contracts under which the corporation provides money, equipment, and personnel.
- The R&D tax credit is an incentive for the corporation (1) in making positive decisions on marginal projects, and (2) because credit ameliorates impact on after-tax profit margins of increased R&D spending.

Special Considerations

- No conditions or restrictions are placed on the institutions to which it provides grants of equipment.
- Maintenance contracts are usually provided for the warranty period, after which the institution must absorb the cost.
- The corporation is flexible in structuring research contracts, but its primary concern is access to results; no restrictions are made as to use or publication of results.

Corporate View

- The corporation looks for institutions with necessary technical know-how to perform a project.
- Success of projects is viewed in broad terms. Any advancement of the knowledge base in a particular area is considered a success.

EXAMPLE 9

Circumstances of Arrangements

- Primary motivation of contributions is to help upgrade university research facilities, since many are outdated.
- The corporation hopes to provide well-trained engineers in the fields the corporation is interested in with the hope that there will be a supply of good engineers for future hiring.
- Corporations also make donations with the hope that users will be happy with them and purchase additional products of those corporations.

• Tax incentives are important regarding the level of charitable contributions. This is because the higher the percentage of product cost that can be offset with tax benefits, the greater the number of products that can be donated at the same cost.

• Equipment donations are initiated by colleges interested in obtaining a product and by a corporation when it identifies institutions that are performing research in areas it is interested in. Contacts between the corporation and the institutions have been in existence prior to some contributions, although this is not true in a large number of instances.

Special Considerations

• Equipment is not usually provided under research contracts, which are normally with large research institutions. The reason for this is that when the corporation enters a research contract, it does not have adequate personnel on hand to do the work itself; it looks for colleges or universities with facilities in place in the particular field of study and specialized personnel.

• Basic research contracts are not often entered into, since they will not necessarily provide the corporation with any direct benefits and they are difficult to justify to shareholders. Also, since a fair amount of basic research is performed at the corporation in fields it is interested in, it has less of an incentive to fund basic research elsewhere.

• When a corporation donates equipment, it also installs it and provides the same warranty a paying customer receives. If a service contract is ordinarily provided with the equipment, that is also included. Corporations would be more willing to provide service contracts if additional tax benefits were associated with them.

Corporate View

• The corporation expects colleges to take some responsibility for operating and maintaining the equipment and does not feel that it should incur all costs.

• The corporation has an interest in seeing the property maintained, because if students repeatedly observe the equipment malfunctioning, they will develop a negative image of it and will be less likely to purchase it in the future.

EXAMPLE 10

Circumstances of Arrangements

- Primary concerns are with expertise of the institution and its ability to assist with product application and development.
- Tax incentives make scientific contributions and research contracts more desirable.
- Arrangements result from informal contacts between corporate and university counterparts.

Special Considerations

- There is no quid pro quo for contributions of scientific equipment, although access to data regarding equipment use is anticipated.
- If research produces any patentable results, the corporation acquires a license.

Institution's View

Generally there is a favorable perception. If institutions were not happy, they would not continue to accept equipment and undertake research arrangements.

Corporate View

Favorable feedback has been received. There was only one instance where an arrangement was not considered successful.

EXAMPLE 11

Circumstances of Donations

Research and Development

- In the case of research and development projects, the company is mainly looking at what it can receive in return, such as technology that can be marketed or put to use in-house for designing new products (e.g., software).
- Marketing of equipment is also important in the hope that (1) institutions will purchase additional equipment from the

donating company, and (2) that students' experience with the equipment will encourage future sales.

- Receipt of proposals in which the company is interested and a proven capacity to conduct high-quality research are influential in decisions to donate equipment for R&D contracts.
- Tax benefits are helpful in the decision to donate.

Scientific Equipment

- Tax benefits are important in the decision to donate. The company prefers to donate more expensive items, since there is a higher markup and they can take advantage of scientific equipment deductions.
- Major contributions were made to one institution for the following reasons: the company could not enter into an R&D contract, since the university will not provide exclusive rights to anyone; informal feedback is useful to the company regarding equipment performance; the institution has a good research reputation; close personal ties have developed over the years, since many high-level employees are graduates of that university; and since the company's engineers will be working on the equipment with that university's counterparts, the company will have first-hand knowledge of the information being developed and its possible uses (the type of work the equipment is being used for is important to the company).

Special Considerations

- The university holds the copyright or patent, but the company has nonexclusive license with no royalty payments to the university.
- The company has the right to review material before it is published to ensure that no proprietary information is released.
- No special considerations are involved for scientific equipment contributions. The equipment is given outright without restrictions.

Institution's View

The company was not aware of any specifics.

Corporate View

The company is happy with the past record of a number of institutions. It has recently dramatically increased the level of contributions and has not yet received the results of most new projects.

SOURCE: Coopers & Lybrand.

APPENDIX 4

Prepared Under the Direction of the
Ad Hoc Interagency Steering Committee on Academic Research Facilities
with the Assistance of the
NSF Task Group on Academic Research Facilities

ADEQUACY OF ACADEMIC RESEARCH FACILITIES

A Brief Report of A Survey of Recent Expenditures and Projected Needs in Twenty-Five Academic Institutions

April 1984

Adequacy of Academic Research Facilities*

ABSTRACT

Recent studies have raised serious questions about the adequacy of academic research facilities -- the bricks and mortar (and mobile or remote research spaces such as ships, airplanes, aquaculture facilities, and monitoring stations), which house and support academic research and research instrumentation. An ad hoc interagency steering committee was formed in November 1983 and is planning a detailed study of academic research facilities. The committee has recently analyzed data on past expenditures and future needs for academic research facilities as derived from capital facilities planning documents of 25 major research institutions which perform about 38% of all federally funded research and development at universities and colleges. From a scaling of these results, it is estimated that about $1.3 billion per year of construction, remodeling, and refurbishment of science, engineering, and medical research facilities is currently being planned by all universities and colleges over the next five years. This estimate is consistent with a 1981 study of 15 institutions carried out by the Association of American Universities. As a percentage of total expenditures, the findings are also consistent with capital outlays at industrial research and development laboratories, and at the university administered Federally-Financed Research and Development Centers.

Introduction

Several recent studies[1-3] of academic research capabilities concluded that the quality of research instrumentation in university laboratories has seriously eroded. Strengthened programs in the Department of Defense, the National Science Foundation and other Federal agencies are now addressing the replacement and renewal of research instrumentation. However, these same studies have also raised serious questions about the adequacy of academic research facilities -- the bricks and mortar, (and mobile or remote research spaces such as ships, airplanes, aquaculture facilities, and monitoring stations), and services which house and support the research instrumentation.

*Prepared under the direction of the Ad Hoc Interagency Steering Committee on Academic Research Facilities with the assistance of the NSF Task Group on Academic Research Facilities. (Lists of members in the Appendix).

More recently, Federal Agencies and the Congress have received many expressions of concern that deteriorating research facilities are becoming a serious problem for academic scientists and engineers, materially impairing their ability to work competitively at the frontiers of scientific and engineering knowledge. The House Authorization Act for the FY 1984 Budget of the Department of Defense directed that a study be undertaken by the Secretary of Defense on the need to modernize university science and engineering laboratories essential to long-term national security needs. The Congress also directed NSF to be an aggressive lead agency in encouraging other Federal agencies, state and local governments, and the private sector to support the renewal of university research facilities, and encouraged the Foundation to estimate the magnitude of the current facilities problem and to assess the success of programs for facilities renewal. Furthermore, during the past 30 years the National Institutes of Health have provided major support for health research facilities construction, and the Congress has periodically requested assessments of the status and needs for these research facilities.

Interagency Steering Committee

In view of the important role that a strong academic research effort plays in underpinning the Nation's economy, health and national defense, the Department of Defense, the National Institutes of Health, the Department of Energy the U. S. Department of Agriculture, and the National Science Foundation are cooperating in an effort to determine the magnitude of the problem related to academic research facilities. An ad hoc steering committee formed with representation from these agencies is planning an in-depth study of academic research facilities. The objective of this study will be to obtain a detailed understanding of the condition of academic facilities currently being used for science, engineering, and medical research and the estimated future needs for construction, remodeling and refurbishment. It is presently planned that this study will be carried out by the National Academy of Sciences. An internal NSF Task Group has also been formed to examine available data on research resources, determine what additional information is needed, develop a credible study design, and work with the interagency steering committee in formulating a government-wide study of academic scientific and engineering research facilities.

Initial Study

Discussions with a number of university presidents indicated that their institutions already had prepared five-year facility plans as well as detailed figures on expenditures for new construction and the remodeling and refurbishment of existing structures over the past five year period and were willing to share the information with the interagency steering committee. Such information was subsequently requested and received from 25 major research institutions which perform about 38% of all federally-funded research and development at universities and colleges. From an analysis of these data, it is estimated that about $495 million per year of construction, remodeling, and refurbishment of science, engineering, and medical research facilities is planned by these 25 institutions over the next five years. (See Table I for a breakdown by discipline.) If these plans are scaled up in proportion to the share of federally-funded R&D, all universities and colleges would require over the next five years about $1.3 billion per year for these purposes. This estimate is consistent with a 1981 survey of 15 universities carried out by the Association of American Universities[3]. Both estimates are probably conservative because the plans were constrained by the perceived availability of funds. The planned major study will obtain more detailed and definitive data, and could well result in a higher figure.

Other sources of data were analyzed to see how the estimate of $1.3 billion per year compared. A private-sector survey[4] of industrial research and development laboratories found that 12.7% of total R&D funds are spent on R&D plant. An NSF survey[5] shows that the university-administered Federally-Financed Research and Development Centers (FFRDC'S) spent 13.6% of their total R&D budget in FY 1983 on R&D plant. Based on the estimated[6] $7.8 billion total R&D at universities and colleges in 1984, these figures would predict a range of $990 million to $1.06 billion for total R&D plant expenditures at universities and colleges. The slightly higher estimate of need from our recent study may result from pressure to recover from past underinvestment. These figures should also be compared to the estimated[7] 1984 federal obligation of $40 million to universities and colleges for R&D Plant, and the 1981 figure[8] of $155 million for the total Federal contribution to science and engineering facilities for research, development, and instruction. (no breakdown is available).

Table I

Recent Survey of Facilities Expenditures and Needs at 25 Major Academic Research Institutions

- Summary of past and planned capital expenditures from an analysis of long-range plans.
- The 25 institutions supplied existing planning documents (typically 5 years) and data on past plus present (usually 1983) capital expenditures (typically 5 years).
- These institutions received 38% of the total Federal R&D obligations to universities and colleges in Fiscal Year 1981. They performed 34% of all academic R&D in Fiscal Year 1981.
- Although planning cycles were typically 5 years, they varied from two to seven years. Therefore, the data are standaradized as yearly averages.

	($ millions)	(current dollars)	No. of Institutions
Past & Current			
Avg. annual	$185		22
Future			
Avg. annual	495		25
Future by Field (supplied by 22 respondents)			
(Avg. annual)		%	
Engineering	77	16	15
Phys. Sci., Math., Comp. Sci.	121	26	15
Medical Sci.	94	20	14
Agric. Sci.	35	7	7
Life Sci.-Bio.	65	14	13
Environmental	28	6	6
Other	50	11	11
	470	100	

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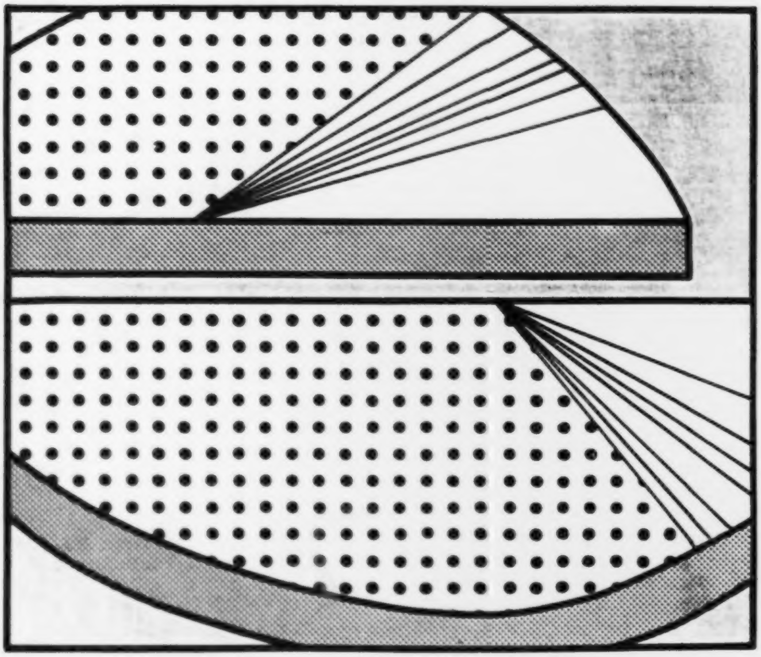
APPENDIX 5

NIH Program Evaluation Report

Academic Research Equipment and Equipment Needs in the Biological and Medical Sciences

Executive Summary

April 1985



U.S. Department of Health and Human Services
National Institutes of Health

NIH Program Evaluation Report

ACADEMIC RESEARCH EQUIPMENT AND EQUIPMENT NEEDS IN THE BIOLOGICAL AND MEDICAL SCIENCES

Executive Summary

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April 1985

This project, Project Evaluation No. NIH-83-311, Contract No. NO1-OD-3-2120, received support from the evaluation set-aside Section 513, Public Health Service Act.

EXECUTIVE SUMMARY

Because of continuing concerns about the age and condition of research equipment in academic institutions, and about the effect of obsolescent equipment on the quality of research in the nation's universities and medical schools, the Congress of the United States charged the National Science Foundation with conducting inventories of, and analyses of the needs for, scientific instrumentation.[*] NSF initiated a feasibility study to determine how pertinent information could be obtained and how suitable indicators of the status of research instrumentation could be developed. That study was followed by specifications for a baseline national survey, which was funded by NSF as a two-phase study starting in 1982. Using a stratified probability sample of 43 universities, the Phase I survey of existing research instruments and instrumentation needs was conducted during the 1982-83 academic year for the physical and computer sciences and engineering. The report of this survey is available from the National Science Foundation.[**]

For Phase II of the study, which encompasses the biological, agricultural, and environmental sciences, the National Institutes of Health joined the National Science Foundation by funding a survey of the biological sciences in medical schools to provide a comprehensive picture of instrumentation in those sciences. NIH also provided for a limited study to determine the feasibility of obtaining the same data for medical (i.e., clinical) sciences as for the biological sciences. For this purpose departments of medicine were chosen. After a stratified probability sample of 24 medical schools was selected, Phase II was conducted during the 1983-84 academic year. The results of the Phase II survey for the biological sciences and departments of medicine are the subject of this report.

---

[*] An Act to Authorize Appropriations for the National Science Foundation for Fiscal Year 1980, and for Other Purposes. Public Law 96-44, Section 7.

[**] Academic Research Equipment in the Physical and Computer Sciences and Engineering: An Analysis of Findings from Phase I of the National Science Foundation's National Survey of Academic Research Instruments and Instrumentation Needs. Westat, Inc., December 1984.

Overview

From the results of this study of instrumentation needs and instrument systems in the biological sciences and departments of medicine, it is apparent that there are deficiencies in the current levels of instrumentation. The extent of the deficiencies varies significantly among the subfields of research. More advanced instrumentation is needed to allow investigators to perform critical experiments which cannot now be adequately conducted. Better maintenance and repair facilities are needed. Although 18 percent of the current national stock of equipment is considered state-of-the-art, that status is lost very rapidly; the need for replacement by upgrading is continuous and of the highest importance.

Department-Level Findings

More than half of the heads of departments/facilities, in assessing the needs and priorities of their departments, stated that critical scientific experiments could not be conducted because their departments lacked appropriate instrumentation. This was more often stated for the biological sciences than for departments of medicine, and for public institutions than for private institutions.

The capability of existing equipment to enable researchers to pursue their major interests was rated excellent for tenured faculty by only one-sixth of the departments, while over one-fourth regarded their capability as insufficient. For untenured faculty the proportion of equipment rated insufficient was one-third. More than twice as many graduate school departments as departments in medical schools answered "insufficient," however, and three times as many departments in public institutions as in private institutions did so. Compared with other fields of science, the current stock of equipment in the biological sciences as a whole was more favorably assessed than in any other field, but this was primarily due to medical schools. For biological science departments in graduate schools, the degree of insufficiency matched that given for graduate school departments in other fields, such as physical sciences and engineering.

The same patterns were found for assessments of instrumentation support services (i.e., machine and electronics shops), with about half of the departments calling them insufficient or nonexistent. Departments of medicine considered their support better than did the biological sciences, and private institutions better than public institutions.

Although these assessments are based not on quantitative data but rather on informed opinion, the consistency with which some large groups report more inadequacies than other groups indicates a widespread perception of a problem.

If increased Federal funding were available for purchase of research equipment, two-thirds of heads of departments/facilities would put funds into instruments costing between $10,000 and $50,000, while another one-fifth desired instruments between $50,000 and $1 million. Private institutions wanted more instruments in the upper range than public institutions.

In other fields of science, there was more of a need for instruments in the range of $50,000 to $1 million than was found in the biological sciences, and even for systems costing above $1 million -- which none of the department heads in the biological sciences mentioned as a top priority need.

When asked to list the three research instruments costing between $10,000 and $1 million that were most urgently needed, department heads often listed various types of preparative instruments. For most disciplines, these were the most frequently needed items. Nearly 80 percent of the instruments mentioned were in categories where the median cost of the instrument was under $75,000. Instruments with a median cost over $100,000 most frequently mentioned were electron microscopes and NMRs.

The biological sciences and departments of medicine spent a total of $158 million on research equipment costing over $500 in FY 1983, and an additional $36 million on maintenance and repair. The mean amount spent for research equipment in FY 1983 was $48,000 per doctoral degree awarded annually. The mean amount per faculty-level researcher was $5,900. Medical schools spent about twice the amount per doctoral degree and researcher as graduate schools, and private institutions considerably more than public institutions.

The National Stock of Academic Research Equipment

There were over 21,000 instrument systems in the current inventories of the biological sciences and departments of medicine, with an aggregate purchase cost of $555 million. In terms of constant 1982 dollars, the cost of these instruments is estimated at $863 million. The biological sciences had more instrument systems than any other field of academic science, but the mean cost per instrument system ($27,000) was the lowest for any field except agricultural sciences.

About three-fourths of all presently existing academic research instruments in the biological and medical sciences cost between $10,000 and $25,000. Only five percent cost between $75,000 and $1 million, but they accounted for one-fourth of all funds spent for equipment.

Since the amount of research activity in the several biological sciences subfields varies considerably, numerical comparisons between the subfields are dominated by the relative "size" of each enterprise. In an attempt to normalize between-subfield and institutional comparisons, instrument numbers and costs were calculated per researcher and per graduate degree awarded. The resulting ratios are indices only and do not represent actual one-time costs per researcher or per degree awarded. Mean dollar amount of research instrumentation per researcher in the biological sciences was about $21,000, but the amount in medical schools per researcher was 50 percent higher than in nonmedical schools. For departments of medicine, the mean equipment investment per researcher was $15,000. Mean aggregate equipment cost per doctoral degree awarded in 1982-83 in the biological sciences was $143,500, but for medical schools that cost was more than twice as much as in nonmedical schools. Private institutions had higher investments per researcher and per graduate degree than public institutions.

State-of-the-art instruments constituted 18 percent of the national stock in 1983, although the percentage was larger in private institutions than public institutions. Another 65 percent were in active research use, although not classified as state-of-the-art. Instruments that were not in active use because of technological obsolescence or inoperable mechanical condition, but that were still physically present at the institution, constituted another 16 percent of the national stock. Departments of medicine, however, had twice as large a percentage of obsolete or inoperable instruments on their inventories as the biological sciences.

Age and Condition of Academic Research Equipment

For all instruments in the national stock, 44 percent were from 1 to 5 years old, and 27 percent were over 10 years old. Omitting the inactive systems from consideration, the proportion of instruments aged 1 to 5 years was 50 percent, and 22 percent were over 10 years old. For instrument systems that were in active research use, departments of medicine had a higher proportion of newer instruments than did the biological sciences, and private institutions were higher than public institutions. Compared with other fields of science, instruments in the biological sciences were somewhat older.

Most state-of-the-art instruments in 1983 were relatively new. Fifty percent of instruments purchased in 1983 were state-of-the-art, but of those purchased two years earlier (in 1981), only 37 percent were still considered state-of-the-art. Six-year old instruments were classified as state-of-the-art only 13 percent of the time. Altogether, 85 percent of the state-of-the-art instruments were from 1 to 5 years old, and only 3 percent were over 10 years old.

About half of all instrument systems actively in use for research were in excellent working condition. As would be expected, there is a relationship between working condition and age of the instrument. Thus, 78 percent of instruments from 1 to 3 years old were in excellent condition; of instruments 4 to 6 years old, 57 percent were in excellent condition; and of those 10 to 12 years old, only 26 percent were rated as excellent. Accompanying this decline in operating condition with age of instrument was the "retirement" of instruments as they got older. In the biological sciences, 60 percent of instruments that were inactive (presumably because of mechanical or technological obsolescence) were over 10 years old.

Of the state-of-the-art systems, which were relatively new, 85 percent were considered to be in excellent condition. Only 44 percent of those not considered state-of-the-art were in excellent condition, however. These "other" systems were considerably older and they constituted nearly 80 percent of all equipment in active use.

A substantial amount of other than state-of-the-art equipment is to be expected. Much laboratory research does not require the most advanced instrumentation. A problem arises, however, when investigators using non-state-of-the-art equipment do not have access to more advanced equipment when needed. This problem was found frequently; nearly half of the non-state-of-the-art instruments in research use were the most advanced instruments of their kind to which users had access. This situation is an obstacle for investigators attempting to engage in more sophisticated research. The entire research effort in the biological sciences is hindered when problems such as mechanically unreliable equipment and lack of access to advanced instrumentation become prevalent.

Funding of Equipment in Active Research Use

Almost all research instruments (94%) in the biological sciences and departments of medicine were acquired new. Sources of funding were evenly split between Federal and non-Federal sources for the biological sciences, but for departments of medicine, nearly two-thirds of the funds came from non-Federal sources. For private institutions, a larger proportion of equipment funds came from Federal sources than for public institutions.

NIH was the principal source of Federal funds for acquisition of research equipment in the biological and medical sciences, contributing 44 percent of all funds for medical schools and 31 percent for graduate schools. NSF was the only other significant Federal source, contributing a larger proportion of graduate school funds than of medical school funds. The institutions were the major source of non-Federal funds. State governments and private foundations gave only small amounts for research equipment. The amount contributed by business and industry for equipment was negligible.

NIH funds, while accounting for 38 percent of all equipment purchases, contributed 47 percent of the support for purchases of instruments in the $10,000 to $25,000 range but only 28 percent of the dollar support for existing equipment costing $75,000 or more. Institutions, however, which contributed 37 percent of all funds for equipment, purchased 31 percent of the instruments costing under $25,000 and 41 percent of those costing $75,000 or more. NSF-supported purchases for equipment followed the same pattern as that for institutions.

Sixty percent of all biological science instruments received full or partial Federal funding, compared to 48 percent of those in departments of medicine.

Location and Use of Academic Research Equipment

About 65 percent of all equipment in the biological sciences and 70 percent in departments of medicine were located in the laboratories of individual investigators. The remainder were in inherently shared-access facilities, mostly department-managed common laboratories. Costly instruments were frequently located in the inherently shared-access facilities; this held true to a greater extent for graduate schools than for medical schools, and for public institutions than for private institutions. Older instruments were also more likely to be located in inherently shared-access facilities.

The location of most instruments within laboratories of individual investigators did not necessarily mean that they were not shared. The mean number of users of all instruments was 11 per instrument. The large majority of instrument systems were available for general purposes, as opposed to being dedicated for specific experiments. For these general purpose instruments, the mean number of users was almost 12 per instrument.

About 95 percent of all instruments in the biological sciences were used by faculty within the same department, and 85 percent were also used by graduate students, medical students, and postdoctorates from the departments. Additionally, 36 percent were used by faculty from other departments in the institution. Visiting researchers from other universities and visiting nonacademic researchers used the more costly instruments far more frequently than the lower cost ones; this held true also for researchers from other departments at the same institution.

The average instrument in an investigator's laboratory was freely accessible to other research investigators, as evidenced by the numbers of users and the origins of users. From this observation, together with the finding that 35 percent of all instruments were located in facilities that are -- by their very nature -- shared-access, it is evident that sharing of research equipment is common in academic facilities.

Maintenance and Repair of Academic Research Equipment

Only 16 percent of departments in the biological and medical sciences considered their maintenance and repair (M&R) facilities as excellent. Nearly 50 percent reported either insufficient or nonexistent facilities. On the whole, departments of medicine were more satisfied with their M&R facilities than were departments in the biological sciences. All departments of medicine had such facilities, while 18 percent of biological science departments did not.

In FY 1983, 22.5 cents were spent on M&R for every dollar spent for new equipment. The mean expenditure per department for M&R was $30,200. Nearly two-thirds of this amount was spent for service contracts and field service as needed. Service contracts, used more frequently than any other means of servicing instruments, cost an average of $2,300 per instrument, compared to $700 per instrument for field service and less for university-based M&R staff and research personnel, who sometimes performed this function.

The amount spent per instrument for M&R rose after the instrument became six years old. While the overall mean expenditure per instrument was $1,100, it was $900 for those between 1 and 5 years old, and over $1,300 for those over 5 years of age. The mean M&R expenditure for instruments costing from $75,000 to $1 million, $6,300, was far more than the $700 expended for M&R for those costing between $10,000 and $29,999.

Group Comparisons

Thus far, findings have been summarized with respect to topic areas. In addition, numerous differences have been observed among groups of institutions, among subfields of research within the biological and medical sciences, and between the biological sciences and the other fields of science encompassed in the larger two-year study of academic research equipment. These group comparisons are briefly summarized here.

Differences Among Institutions

(1) Medical and graduate (nonmedical) schools. Levels of investment in research instrumentation were substantially higher for medical schools than for other academic institutions. For all indices examined -- equipment per institution, per instrument, per faculty-level researcher, per doctoral degree awarded -- medical schools had larger instrumentation investments, both aggregate and current, than graduate (nonmedical) schools.

(2) Private and public institutions. Privately controlled institutions consistently showed an advantage over public institutions on a number of important dimensions. Their research instruments generally cost more, were newer, and were better able to meet research needs. Private institutions also had better maintenance facilities and spent more for maintenance and repair of their instruments.

Differences Among Subfields of Research in the Biological Sciences

Certain subfields of research stand out from the others in some characteristics. A brief summary of major differences follows.

- Biochemistry had the largest number of instruments costing over $10,000 -- nearly 4,500. It also had a higher proportion of instruments funded by Federal agencies than any other subfield.

- In many respects, molecular/cellular biology appeared to be the best equipped research subfield. It had the second largest number of instruments, 2,900. In percentage of instruments in excellent working condition, it ranked very high. Department heads in this discipline were more satisfied with the quality of their current instrumentation than in any other subfield. Equipment expenditures per faculty researcher in 1983 exceeded by a large amount those for all other disciplines.

- Anatomy and pathology were two of the smaller subfields in numbers of instruments. They had the highest costs per instrument, $32,000 and $31,000 respectively. Both subfields, particularly anatomy, also had unusually high proportions of instruments over 10 years old in active research use.

- Zoology, botany, and food/nutrition were disciplines found almost entirely in nonmedical subdivisions of universities. They were the three subfields with the smallest numbers of instruments. Very high proportions of department heads stated that their staff could not perform critical experiments in these disciplines because they lacked appropriate instrumentation.

Food/nutrition had the lowest cost per instrument ($22,000) of any subfield, the poorest maintenance, and had, by far, the lowest percentage of Federal funding for its equipment.

Differences Between Departments of Medicine and Biological Science Fields

Departments of medicine, included in the survey as an experiment to assess the feasibility of obtaining instrumentation indicators for medical (clinical) sciences, apparently can provide data on samples of research instruments as easily as the biological sciences. With respect to Department/Facility Questionnaires, however, it was learned that some of the larger, more diverse departments of medicine had difficulty in assembling expenditure, funding and needs data for all the clinical fields subsumed within their jurisdictions. A better approach to collecting such data might be to go directly to each of the component clinical programs or subunits of departments of medicine.

For most of the analyses performed in this report, departments of medicine (and presumably, the clinical sciences) had somewhat different results than the biological sciences. Departments of medicine apparently retired instruments at an earlier age than did the biological sciences. Within medical schools, the average costs of equipment per researcher were nearly twice as large for the biological sciences as for departments of medicine. This difference on an index of equipment intensity is probably a function of the kinds of research performed by physician-researchers in clinical departments, compared with those in the basic biological sciences. Whereas over half of the funds for purchase of equipment in the biological sciences came from Federal agencies, 38 percent of equipment funds came from those sources for departments of medicine. The difference was made up by institutional funds, indicating a possible difference in institutional resources between the clinical and biological sciences.

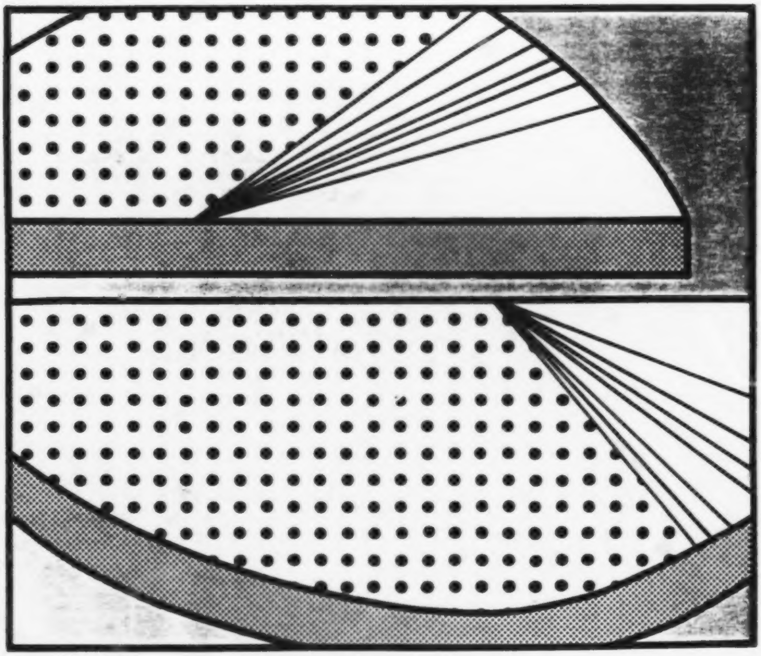
Differences Between Biological Sciences and Other Fields of Science

The biological sciences differed from the other fields of science addressed in the field survey. They accounted for 38 percent of the instruments in all the fields surveyed; the next largest field was the physical sciences, with 25 percent of all instruments. The mean cost per instrument in the biological sciences was $27,000, compared to $41,000 for the physical sciences and $35,000 for engineering. Instruments in the biological sciences were somewhat older than those in other fields, but there were proportionately fewer instruments in the national stock in biology that were technologically or mechanically obsolete. The average instrument in the biological sciences was used by somewhat fewer investigators than was the case in other fields. The funding pattern for the biological sciences was unlike that for any other field, because of the prominence of NIH as a funding source in the biological sciences: NIH directly contributed 39 percent of the costs of all academic instrumentation in this field.

APPENDIX 6

NIH Program Evaluation Report
Academic Research Equipment and Equipment Needs in the Biological and Medical Sciences

April 1985



U.S. Department of Health and Human Services
National Institutes of Health

NIH Program Evaluation Report

ACADEMIC RESEARCH EQUIPMENT AND EQUIPMENT NEEDS IN THE BIOLOGICAL AND MEDICAL SCIENCES

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April 1985

This project, Project Evaluation No. NIH-83-311, Contract No. NO1-OD-3-2120, received support from the evaluation set-aside Section 513, Public Health Service Act.

HIGHLIGHTS

- This report presents findings from a survey of existing research instruments and instrumentation needs in biological science departments and facilities in a national sample representative of the 249 U.S. universities and medical schools with the largest R&D funding. The data are part of a larger survey of academic research instrumentation in all major fields of science and engineering. The survey focuses on instrument systems in the $10,000 - $1 million range.

- As a test of the feasibility of collecting data for clinical fields as well as for basic science fields, medical school departments of medicine were included in the data collection. No major feasibility or response problems were encountered and data from these departments were included in the analysis of findings.

- At all levels of data collection, from central administration to department heads to faculty researchers, response rates were extraordinarily high -- in the 95-100 percent range. This exceptional response appears to indicate high levels of interest and concern about the adequacy of existing research equipment.

- Less than one in five biological science department heads characterized the adequacy of their current research instrumentation as "excellent," and nearly 60 percent reported that there are important subject areas in which researchers in their departments cannot conduct critical experiments because of a lack of necessary equipment.

- The 1983 national stock of academic research equipment in the biological sciences and departments of medicine is estimated to have an aggregate original cost of $555 million and a replacement cost (in constant 1982 dollars) of $863 million. Per faculty-level researcher, the average amount of equipment (in original-cost dollars) is $21,200 per person.

- Most items of equipment in the 1983 national stock were comparatively inexpensive. The mean purchase cost per instrument system was only $27,000 in this field, far lower than for most other major fields of science and engineering.

- The unit costs of the most urgently needed research equipment, as reported by biological science department heads, were also comparatively low. Many of the most frequently mentioned items of needed equipment had purchase costs of $30,000 or less.

- Only 18 percent of instruments in the 1983 national stock were classified by their principal users as state-of-the-art. About that same amount (i.e., 16 percent of the total stock) appeared to be totally obsolete and no longer useful in research.

- Of the equipment in active research use in 1983:
  - Half the systems were in some degree of disrepair (i.e., in less than excellent working condition);
  - 80 percent were not state-of-the-art; and
  - Of these latter instruments, half were the most advanced instruments to which their users had access.

- Facilities for the maintenance and repair of research instrumentation were characterized as insufficient or nonexistent by nearly half of the department heads.

- About 22.5 cents were spent for maintenance and repair (M&R) of research instruments in FY 1983 for every dollar spent to acquire equipment in that year. Most M&R was performed through service contract or field services as needed. The mean cost per instrument for a service contract was $2,3000, compared to $700 for field service and less for service performed by university-based personnel.

- The mean expenditure per instrument system for M&R in 1983 was $1,100. It was $900 for instruments up to 5 years old, but more than $1,300 for those six years and older. While an average of $700 was spent for M&R on instruments with an original purchase cost less than $25,000, $6,300 was spent in 1983 for an instrument costing between $75,000 and $1 million.

- Most equipment that was used for research in 1983 was used extensively. The mean number of users per system per year was 11, and most systems were used by several types of users (faculty, graduate students, etc.) both from the host department and from other locations.
- Within the general parameters of need/condition/ obsolescence just described, private institutions were typically somewhat better equipped than public institutions: the research equipment in private institutions tended to be newer, more costly, more voluminous and in better repair than that in public institutions. Similar differences, in favor of medical schools, were found between medical schools and nonmedical academic institutions.

ACKNOWLEDGMENTS

The two-phase, baseline National Survey of Academic Research Instruments and Instrumentation Needs was designed and conducted by Westat, Inc., initially under the sponsorship and direction of the Universities and Nonprofit Institutions Study Group, Division of Science Resources Studies, of the National Science Foundation (NSF). Phase I of the research, involving collection of data for the physical and computer sciences and engineering, was conducted under NSF Contract No. SRS-8017873. Phase II, a part of which is the subject of this report, involved collection of data for biological sciences, departments of medicine, and other fields; it was supported jointly by NSF under the above contract and by the Program Evaluation Branch, Office of Program Planning and Evaluation (OPPE) of the National Institutes of Health (NIH). The NIH support provided for collection and analysis of data from a nationally representative sample of medical schools (under NIH Contract No. NO1-OD-3-2120), in addition to the NSF-sponsored data collection from nonmedical components of U.S. colleges and universities. Preparation of this report was also supported by the above-referenced NIH contract.

At the NIH Program Evaluation Branch, Helen Hofer Gee, Ph.D. (Branch Chief), and Charles Sherman, Ph.D. (Project Officer), performed major roles in the development of the Phase II design and analysis plan and provided technical oversight during the survey. In addition, major contributions were made by Marvin Cassman, Ph.D. (National Institute of General Medical Sciences), W. Sue Badman, Ph.D. (Division of Research Resources, NIH), and Rachel E. Levinson (OPPE, NIH), who developed the instrument typology that was used for the analysis of instruments identified by respondents as being most urgently needed at the current time.

The following contractor staff performed significant roles in the survey and in preparing this report:

Lance Hodes, Ph.D., Westat Corporate Officer-in-Charge
Kenneth Burgdorf, Ph.D., Principal Investigator and Second Author of Report
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Kristine White, Editor
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In addition to the NIH and Westat project teams, the project's Phase II Advisory Group made many valuable contributions both in the refinement of the research design and in the assessment of the statistical findings. The members of this group are listed in Appendix D.

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1. INTRODUCTION

1.1 Background of the Survey

First-rate research requires first-rate equipment. Research instruments in the biological and medical sciences perform a variety of functions, such as: sorting cells, visualizing tissues, sequencing proteins or nucleotides, measuring physical properties, and performing complex computations. Scientific instruments must be in proper working condition, capable of performing their functions, and possess the technological capacity to obtain the kinds of data, quantities of data, and the resolution of data required by the research problems at the frontiers of present knowledge. Lacking such instrumentation, investigators are either severely handicapped in their ability to design experiments and to collect data, or they must turn away from some of the most important problems of their discipline.

The evolution of scientific research problems and equipment has spawned increasingly complex and expensive instrumentation. Replacement of obsolete instruments, as well as acquisition of instruments of totally new design and capabilities, is frequently necessary to maintain the level of research that will keep the United States at the forefront of scientific knowledge and technology.

Many advances in scientific knowledge and in instrument technology have originated in university-based laboratories since World War II. However, since the early 1970's, colleges and universities have experienced falling student enrollment and rising costs in all phases of operation. The resulting fiscal retrenchments have reduced the ability of institutions to fund the purchase of scientific research equipment at the very time that equipment costs have been rapidly increasing. Simultaneously, Federal support for the purchase of equipment has been declining.[1] For example, the National Institutes of Health, which is the principal source of support for the biological sciences, has experienced a decline in the percentage of research grant and contract awards earmarked for the acquisition of research instruments. Table 1-1 shows that the percentage of research project grant funds expended for permanent laboratory equipment declined from nearly 12 percent in 1966 to less than six percent by 1974. Table 1-2 presents a more recent time-series showing the amount and proportion of research and shared instrumentation program awards budgeted for equipment. The percentages vary from 4.6 percent in 1975 to 3.7 percent in 1984.

Table 1-1. Percent of NIH research project grant funds allocated for permanent laboratory equipment, fiscal years 1966-1974*

Year	Percent
1966	11.7%
1967	11.8
1968	9.5
1969	7.5
1970	5.9
1971	6.2
1972	6.6
1973	4.9
1974	5.7

*Includes the National Cancer Institute, the National Institute of General Medical Sciences, and the National Heart and Lung Institute. Source: National Science Foundation, Science Indicators, 1974, Table 2-12.

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[1] See Kennedy, Donald. Government Policies and the Cost of Doing Research; Science, 1 February 1985, Vol. 227, pp. 480-484.

Table 1-2. NIH equipment awards, fiscal years 1975-1984*

[Dollars in thousands]

Year	Dollars budgeted for equipment	Percent of total dollars awarded
1975	$ 49,693	4.6%
1976	56,673	3.9
1977	58,697	4.3
1978	68,009	4.4
1979	85,161	4.6
1980	79,327	3.8
1981	73,359	3.3
1982	74,657	3.2
1983	89,512	3.4
1984	109,720	3.7

*Includes all NIH extramural research and shared instrument programs.
Source: NIH internal document.

Evidence has been accumulating that these funding problems have affected the quality of research in universities. A recent survey of 16 prestigious research universities revealed that leading investigators were already experiencing difficulty in performing experimental research at the frontiers of their fields because of the lack of proper instrumentation.[2] While the survey confirmed other accounts of the problem, all of the evidence was anecdotal, and a demand arose for more comprehensive and objective data.

In recognition of the need for "objective information in the area," the House Committee on Science and Technology recommended that the National Science Foundation "conduct inventories of, and analyses of the needs for, scientific instrumentation."[3] The resulting legislation, when enacted and signed into law, directed the Foundation to "develop indices, correlates or other suitable measures or indicators of the status of scientific instrumentation in the United States and of the current and projected need for scientific and technological instrumentation."[4] In response to this mandate, the Foundation initiated a feasibility study in FY 1980: (a) to design quantitative indicators of current status and trends in the stock, condition, utilization and needs for research instrumentation in academic settings, and (b) to assess the availability of this information and determine the most appropriate data sources and methods of data collection. The advisory group for this study included representation from the National Institutes of Health.

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[2] Association of American Universities. The Scientific Instrumentation Needs of Research Universities, Report to NSF, 1980.

The feasibility study, conducted in the fall of 1981 at a national sample of 38 colleges and universities, concluded that it is feasible to obtain reliable quantitative indicators of current status and trends in academic research instrumentation. The feasibility study final report presented recommendations concerning proposed data collection methodologies and statistical indicators to be constructed from the resulting data.[5] Final specifications for the baseline national survey were developed by NSF following extensive review of the feasibility study findings by other Federal agencies and by university scientists and research administrators.

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[3] House of Representatives Report No. 96-61 (1979), p. 30.

[4] An Act to Authorize Appropriations for Activities for the National Science Foundation for Fiscal Year 1980, and for Other Purposes. Public Law 96-44, Section 7.

[5] Indicators of Scientific Research Instrumentation in Academic Institutions: A Feasibility Study. Westat, Inc., March 1982.

1.2 Overview of the Survey

The National Survey of Academic Research Instruments and Instrumentation Needs calls for the development of quantitative baseline indicators of the national status and of emerging trends in the stock, cost/investment, condition, obsolescence, utilization, and need for major research instruments in academic settings.

This baseline survey was conducted in two phases. Phase I, conducted during the 1982-83 academic year at a stratified probability sample of 43 universities, was concerned with existing academic research instruments and instrumentation needs in the physical and computer sciences and in engineering. Phase I was conducted entirely under NSF sponsorship.[6]

The National Institutes of Health joined the study for Phase II, which was conducted during the 1983-84 academic year with the collection of data for the biological, agricultural, and environmental sciences. The same sample of universities that participated in Phase I contributed to Phase II. In addition, a separately drawn sample of 24 medical schools was added, under NIH sponsorship, to provide a comprehensive picture of academic instrumentation in the biological sciences.

A limited study was also undertaken to determine the feasibility of obtaining the same data for medical (i.e., clinical) sciences as for the biological sciences. Departments of Medicine in the medical schools were chosen for this purpose. The particular medical sciences included in Departments of Medicine are

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[6] Academic Research Equipment in the Physical and Computer Sciences and Engineering: An Analysis of Findings From Phase I of the National Science Foundation's National Survey of Academic Research Instruments and Instrumentation Needs. Westat, Inc., December 1984.

not consistent from one institution to another, but include a variety of clinical subspecialty areas. This segment of the study is not equivalent to the sampling survey done for the biological sciences, since no defined set of disciplines is covered, but it can be considered a case study to be evaluated for the possibility of more formal investigation.

In each phase, two kinds of data were collected. First, all departments and nondepartmental research facilities in applicable fields were asked to provide information about the department or facility as a whole, particularly as regards research equipment costs and needs. Department/facility heads provided this information. Second, from equipment listings supplied by the university, a sample of research instrument systems was selected from each department and facility, and the principal investigator (or other knowledgeable individual) was asked to provide information about the sampled instrument's cost, age, condition, use, etc.[7] These latter data were used to construct quantitative statistical indicators of these variables for the national stock of existing academic research instruments in the fields surveyed.

The equipment survey component of each phase was restricted to instrument systems with an original purchase cost of $10,000 to $1 million. Systems above this range are generally well-known throughout the research and policymaking communities and are individually subject to ongoing policy analysis. The lower limit was set at $10,000 for efficient survey coverage. According to the feasibility study, instruments priced at $10,000 or more accounted for over 80 percent of the aggregate costs, but only 10 to 15 percent of the total number of systems, of all academic research instruments costing $500 and over. Also, it was the consensus of the NSF Interagency Working Group advisors that individual pieces of equipment below $10,000 are seldom of critical importance in determining whether an academic scientist or engineer is able to pursue his or her research interests.

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[7] Until very recently, it would not have been feasible to obtain the kinds of equipment lists required for the selection of instrument samples. Most of the computerized university property inventory systems that were so useful in generating sampling lists for the study had come into being, or had been substantially upgraded, within the past 1-3 years.

1.3 Objectives and Limitations of This Analysis

This analysis is concerned primarily with the biological sciences in medical schools and in the nonmedical components of colleges and universities, the latter being referred to as graduate schools. Additional data are reported for Departments of Medicine in the medical schools as part of an exploration of the feasibility of obtaining information on instruments used in clinical research.

The study provides a baseline for measuring future changes in instrument costs, quantity, obsolescence, condition, and utilization. It also provides, for the first time, a set of quantitative statistical indicators for measuring these changes. The statistics presented here function as a snapshot of the current status of instrumentation in academic settings, couched in terms of the indicators. Not only do these figures describe what has been found for 1983 in the biological and medical sciences, but they also permit comparisons with different fields of science. In addition, the most important needs of departments and nondepartment research facilities are summarized in general terms. terms.

While this study offers the potential for assessing changes over time, that potential can be realized only by replications of the survey at suitable periods. To a limited extent, there are some data in the present study that display trends for the last few years of instrument acquisition; these data are suggestive of the total picture but are not definitive, and they need determination from a separate survey.

This survey did not collect information on the total number, cost, and condition of all equipment in academic research settings, since the instruments included were limited to those costing between $10,000 and $1 million. Moreover, in this study no account has been taken of instrumentation that may be available to at least some university and medical school investigators in nonacademic research facilities, a factor that may influence the need for research instruments.

The principal analytic objectives of the present study are: (a) to construct and examine a variety of quantitative statistical indicators of major characteristics of the current national stock of academic research equipment in several fields, and (b) to document differences among research fields and among types of institutions in amount, age, condition, obsolescence, sharing/usage, and perceived current needs for equipment.

1.4 Contents of This Report

This report focuses on statistical findings from the survey of the biological sciences and departments of medicine. There are eight more chapters. Chapter 2 is a brief description of the survey methodology and of the response rates for the survey. Chapters 3 through 9 present statistical findings in each of six broad topic areas:

- Needs and Priorities for Research Equipment: Assessments by Department Heads

- Expenditures for Equipment, FY 1983
- The National Stock of Academic Research Equipment
- Age and Condition of Research Equipment
- Funding of Equipment in Active Research Use
- Location and Use of Research Equipment
- Maintenance and Repair

Chapter 10 is a summary of the principal findings of the survey. The appendices include a set of comparison tables for all fields of science (see Appendix A), offered so that major results for the biological sciences may be compared with those for all other fields surveyed in Phases I and II. The questionnaire forms used in the survey may be found in Appendices B and C. Appendix D lists the members of the project's Phase II Advisory Group, and Appendix E presents informaiton about the statistical precision of the major types of national estimates derived from the survey examples.

2. METHODOLOGY

2.1 Sample Design

2.1.1 Institutions

2.1.1.1 Graduate Schools

The graduate school segment of this study, perhaps more accurately termed the nonmedical school component, consisted of the same set of 43 institutions selected as the stratified probability sample for the NSF Phase I study referenced previously. The "universe" from which this sample was drawn constituted the largest academic research and development (R&D) institutions in the nation: the 157 nonmedical, nonmilitary U.S. colleges and universities that had $3 million or more in separately budgeted science and engineering (S/E) R&D expenditures in any of the fiscal years FY 1977 - FY 1980.[8] One of the sampled institutions, a technical college, had no research equipment in the biological sciences; therefore, this report was based on data collected from 42 sampled institutions.

The 157 institutions in the graduate school universe collectively account for 95 percent of all nonmedical S/E R&D expenditures reported to NSF for FY 1980 by all U.S. colleges and universities. Thus, although the survey represents only a small fraction of the nation's approximately 3,000 postsecondary institutions, it encompasses most institutions with significant capabilities for the kinds of advanced research that require instrumentation in the $10,000+ range. Such capabilities are assumed to be very limited, or nonexistent, at most of the thousands of other U.S. institutions of higher education that have been excluded from the study universe.

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[8] Academic Science R&D Funds, Fiscal Year 1980: Detailed Statistical Tables. Surveys of Science Resources Series, National Science Foundation, 1982 (GPO Publication No. NSF82-300).

In selecting the study sample of 43 institutions, the probability of selection of each institution in the survey universe was approximately proportional to its R&D size, as indicated by its FY 1980 nonmedical S/E R&D expenditures. Within R&D size classes, the proportion of private (or public) institutions in the sample was approximately the same as in the nation as a whole. The design is summarized in Table 2-1.

Table 2-1. Institution sample design, graduate (nonmedical) schools

FY 1980 S/E R&D expenditures	No. institutions in nation			No. institutions in sample		
	Total	Private	Public	Total	Private	Public
Total, all institutions over $3 million	157	53	104	43	15	28
Large institutions, total	38	11	27	23	7	16
Over $90 million	3	2	1	3	2	1
$52.5-$89.9 million	15	3	12	10	2	8
$33-$52.4 million	20	6	14	10	3	7
Smaller institutions, total	119	42	77	20	8	12
$19-$32.9 million	30	11	19	10	4	6
$3-$18.9 million	89	31	58	10	4	6

2.1.1.2 Medical Schools

For the medical school component of the study, a sample of 24 medical schools was selected from the universe of all medical schools with at least $3,000,000 in total NIH awards in 1982.[9] The 92 schools in this universe accounted for 97 percent of all NIH awards made in FY 1982 to U.S. medical schools. For the sample, six schools were selected from each of four strata, as shown in Table 2-2.

Table 2-2. Institution sample design, medical schools

FY 1980 S/E R&D expenditures	No. institutions in nation			No. institutions in sample		
	Total	Private	Public	Total	Private	Public
Total, all institutions over $3 million	92	40	52	24	10	14
Large institutions, total	20	13	7	12	6	6
Over $43.6 million	8	6	2	6	4	2
$25.0-$42.2 million	12	7	5	6	2	4
Smaller institutions, total	72	27	45	12	4	8
$13.5-$24.7 million	18	9	9	6	3	3
$3.1-$13.4 million	54	18	36	6	1	5

The selection procedure was one that maximized overlap with the original NSF institution sample. The probability of selection of each institution in the survey universe was approximately proportional to its FY 1982 NIH award size.

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[9] Summary of NIH FY 1982 Extramural Awards to Medical Schools, Internal document, National Institutes of Health.

2.1.2 Departments and Facilities

At each sampled graduate and medical school, the following departments and facilities were identified as candidates for inclusion in the survey:

- All academic departments in the biological sciences;
- All institutionally operated, nondepartmental research or instrumentation facilities in the biological sciences; and
- Departments of medicine in the medical schools.

All departments/facilities that contained one or more research instrument systems in the $10,000 to $1,000,000 cost range were asked to participate. A total of 195 biological science departments/facilities in the graduate schools and 168 in the medical schools, in addition to 24 departments of medicine, were identified as "in-scope." Each department/facility was asked to complete a Department/Facility Questionnaire concerning its instrumentation-related expenditures, needs and priorities, and sources of funding support. (See Appendix B.)

2.1.3 Research Instruments

The survey was limited to instrument systems that (a) were used primarily for research in 1983 or were intended for such use; and (b) originally cost $10,000 to $1,000,000, including the cost of any separately-purchased, dedicated accessories or components. The sequence of steps taken at each department/facility to obtain a sample of such instruments is described in the following paragraphs.

- A preliminary listing of all $10,000+ items of research equipment was obtained, usually from the institution's computerized central property inventory system. Often, the preliminary lists were overly inclusive, containing in addition to items of research equipment, miscellaneous property such as laboratory and other furniture, physical plant equipment (e.g., exhaust hoods, heating and air conditioning units), field transportation equipment (trucks or vans), secretarial equipment (word processors, reproduction units), and the like.

- After preliminary screening out of entries that were unquestionably inappropriate, a random probability sample of $10,000+ items was selected from each department/facility. All items costing $50,000 or more were included in the survey. For items in the $10,000 to $49,999 range, sampling rates ranged from 100 percent for departments/facilities with from 1 to 11 such items down to a simple random sample of 14.3 percent (1/7) for departments/facilities with 97 or more such items. The intent of this design was to ensure adequate sample sizes for analysis without overburdening large departments and facilities.

Across the 387 eligible departments/facilities in the 66 sampled institutions (42 graduate schools and 24 medical schools), a total of 9,238 equipment items were identified in preliminary listings; of these, 4,555 were selected for the survey sample. Overall, the equipment sample included 190 items costing between $100,000 and $1,000,000; 452 items costing between $50,000 and $99,999; and 3,913 items in the $10,000 to $49,999 range.

- For each sampled instrument, department/facility administrators were asked to arrange for the brief Instrument Data Sheet to be filled in by the responsible principal investigator or other person knowledgeable about the instrument's status, cost, and condition. (See Appendix C.)

2.1.4 Estimation Procedures

In later chapters, all results are reported in the form of national estimates statistically weighted to represent all applicable research departments and nondepartmental research facilities in the biological and medical sciences at institutions in the study universe. As noted earlier, the universe to which survey estimates apply consists of the 157 largest nonmedical R&D universities in the nation and the 92 medical schools with the largest total NIH awards.

The estimation weights that were applied to department/facility questionnaire data were not complex. Since all applicable departments and facilities in a sample university were asked to participate in the survey and since most of them actually did provide survey responses, the estimation weight for each responding department was simply the inverse of the selection probability of the university or medical school in which the department or facility was located, multiplied by a small nonresponse adjustment factor.

Estimation weights for the survey of $10,000 to $1,000,000 instruments were somewhat more intricate. The weight for a completed instrument questionnaire was the product of:

- The university sampling weight -- the inverse of the university's probability of selection;
- The instrument sampling weight -- the inverse of the probability of selection of the particular instrument from the department or facility equipment list;
- An adjustment to the initial instrument sampling weight in situations where the instrument was part of a larger system with two or more separately

listed components in the $10,000 to $1,000,000 range (in which case, the system selection probability was larger than the selection probability for any one component); and

- A nonresponse adjustment, where needed.

Information about the statistical accuracy of national estimates derived from the study samples of departments and instruments is presented in Appendix E.

2.2 Survey Procedures

At each institution, all data collection arrangements were handled by a survey coordinator appointed, for graduate schools, by the office of the president of the university and, for medical schools, by the dean of the school. Typically, coordinators were themselves senior administrators, such as deans of the graduate schools or vice presidents of research. These individuals were responsible for identifying all the relevant departments and facilities; obtaining needed preliminary lists of equipment; and after equipment samples had been selected by the survey contractor, arranging for the distribution, completion, and return of survey questionnaires.

2.3 Definitions

The following definitions and guidelines are provided to assist the reader in using the data in this report.

2.3.1 Field of Science

This report is concerned with two broadly defined fields: (a) biological sciences, and (b) the clinical (or medical) sciences, which are represented by departments of medicine. Nationally, departments of medicine comprise 40 percent of faculty in clinical departments. The bulk of the data was reported either by department type or by subfield of research. Data obtained from the Department/Facility Questionnaire were broken out by department type, based largely on the name of the department or facility. The analysis categories are shown in Exhibit 2-1.

The category of biology, general and n.e.c. (not elsewhere classified), is a combination of biological science departments and facilities that do not fit into any of the other classifications. The majority of these are departments of general (undifferentiated) biology, which are not uncommon in nonmedical schools. However, a few miscellaneous medical school department facilities conducting research in a variety of biological science fields (i.e., cancer research centers and other interdisciplinary biomedical science research centers) are included in this classification.

When findings about instrument systems are based on information from the Instrument Data Sheet, the data are broken out by subfield of research, rather than by type of department. This is because an instrument may be carried on the inventory of a department in one discipline while actually being used in a discipline other than the one implied by the department name. For example, many instruments assigned to departments of general biology were actually used for research in biochemistry or molecular biology. The user of the instrument was asked on the questionnaire to list the principal field of research in which the instrument was employed, and the researcher's description

Exhibit 2-1. Department types and subfields of research for the biological and medical sciences

Biochemistry

Microbiology
    (includes immunology, bacteriology, virology)

Molecular/Cellular Biology
    (includes genetics, embryology, developmental biology)

Physiology/Biophysics

Anatomy

Pathology
    (excludes laboratory medicine, clinical pathology, clinical chemistry)

Pharmacology/Toxicology
    (excludes clinical pharmacology)

Zoology/Entomology
    (includes parasitology)

Botany

Food and Nutrition

Biology, General and n.e.c.
    (includes cancer research centers, interdisciplinary biomedical science research facilities)

Departments of Medicine*

Interdisciplinary, n.e.c.**

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*For subfields of research, the designation is Medical Sciences/ Departments of Medicine, and includes instruments located in other departments.

**This category is used only for subfields of research; n.e.c. means not elsewhere classified.

for classifying the instrument into its subfield of research. There were significant differences between the number of instruments assigned to departments named for a discipline and the number used in the subfield of research carrying the name of that discipline. One designation change was necessary in the parallel naming of the two sets. Several subfields of medical sciences research were present in most departments of medicine. Instruments used for research in one or another of the medical sciences -- most of which were located in departments of medicine -- were given a generic subfield classification of Medical Sciences/Departments of Medicine. A subfield category was also needed to account for a small number of instrument systems that were carried on the inventories of departments in the biological sciences but were actually used in fields outside the biological sciences -- biomedical engineering, chemistry, etc. This subfield category was named "Interdisciplinary, n.e.c."

2.3.2 Institution Control

Institutions were classified according to the nature of the controlling body; i.e., private vs. public ownership.

2.3.3 System

For purposes of data collection, an instrument system was defined as a sampled instrument or component, selected from a department/facility property inventory list, plus any separately acquired "add-ons" or components that, as of December 31, 1983, were dedicated solely for use with the sampled items. The instrument system was the basic counting unit in the equipment survey, and all reported cost figures reflected costs for the full system --

the base unit plus all dedicated accessories. The equipment survey was limited to systems with an original purchase cost of $10,000 to $1,000,000.

2.3.4 1983 National Stock of Academic Research Equipment

In this report, the "national stock" of academic research equipment refers to all instrument systems costing $10,000 to 1,000,000 that, as of December 31, 1983, were physically located at an academic institution in the survey universe and were principally used (or intended for use) in original scientific research in one or more of the fields encompassed by the survey. The term national stock includes systems actually used for research in 1983 as well as existing components of nonoperational systems still under construction at the end of 1983. Research systems that were physically present but inoperable or inactive throughout 1983 are also included as part of the national stock.

2.3.5 Purchase Cost

The purchase cost refers to the manufacturer's list price at the time of original purchase (i.e., when new). For multi-component systems, the purchase cost is the aggregate list price of all components and accessories. Except where clearly specified otherwise, all cost/value/investment statistics in this report refer to system purchase cost.

2.3.6 Acquisition Cost

In this report, this is the actual cost to acquire the instrument system at the present university, including transportation and construction/labor costs. For used, discounted, or rebated equipment, it is the price actually paid to the seller plus transportation and installation costs; for donated, loaned, transferred, or surplus equipment, it is just the transportation and installation costs, if any.

2.3.7 1982 Cost-Equivalent

This is the original purchase cost converted to 1982 dollars using the Machinery and Equipment Index of the Annual Producer Price Index (PPI) to adjust for inflation. Arithmetically, the value is calculated by multiplying the original purchase cost by the ratio of the 1982 Annual PPI for Machinery and Equipment to the index for the year in which the instrument system was originally purchased or constructed.

2.4 Survey Response

In a complex, multistage survey such as this, there are several levels or types of response to consider. The first level is the institution; participation by the institution makes possible all other data collection. The next level is the department, or nondepartmental research facility, with its response to the Department/Facility Questionnaire addressed to the department head. The third level is the faculty researcher asked to complete the Instrument Data Sheet. The final level is the response to individual items on the questionnaires, i.e. the percentage of respondents giving usable answers to each item.

2.4.1 Institution Response

The rate of response for institutions was 100 percent. At each of the 24 sampled medical schools, the deans promptly agreed to participate and appointed coordinators, who arranged for the preparation and delivery of preliminary equipment listings for all applicable departments/facilities and subsequently arranged for the delivery and return of survey materials to and from these departments/facilities. Similarly, there was a 100 percent response rate among the 42 sampled graduate schools that had been sampled in Phase I of the study.

2.4.2 Department/Facility Questionnaires

Completed Department/Facility Questionnaires were received from 95 percent of the department heads -- 367 of the 387 eligible departments and facilities. Table 2-3 reports these returns in detail. Three of the department categories had a 100 percent response rate. With the exception of departments of medicine, 91 percent of the questionnaires were returned. Departments of medicine had a response rate of 83 percent. In a few departments of medicine, the organizational structure was such that an overall response for all the clinical subdivisions in those departments was not feasible. There was essentially the same response rate for institutions with large R&D expenditures as for those with small expenditures. Departments in private institutions, however, responded with slightly less frequency than did those in public institutions (90 percent vs. 97 percent).

Table 2-3. Department/facility survey response rates: Biological and Medical Sciences

Characteristics	Total department/facilities			Graduate school department/facilities			Medical school department/facilities		
	Sample	Response	Rate	Sample	Response	Rate	Sample	Response	Rate
Total, all department/facilities	387	367	94.8	195	190	97.4	192	177	92.2
Departments									
Biological sciences, total	363	347	95.6	195	190	97.4	168	157	93.5
Biochemistry	45	41	91.1	23	21	91.3	22	20	90.9
Microbiology	42	41	97.6	19	19	100.0	23	22	95.7
Molecular/Cellular biology	27	25	92.6	14	13	92.9	13	12	92.3
Physiology/Biophysics	37	34	91.9	11	11	100.0	26	23	88.5
Anatomy	24	23	95.8	5	5	100.0	19	18	94.7
Pathology	28	27	96.4	6	6	100.0	22	21	95.5
Pharmacology/Toxicology	28	27	96.4	4	4	100.0	24	23	95.8
Zoology/Entomology	29	29	100.0	26	26	100.0	3	3	100.0
Botany	18	18	100.0	18	18	100.0	-	-	-
Food and Nutrition	22	22	100.0	22	22	100.0	-	-	-
Biology, general and n.e.c.	63	60	95.2	47	45	95.7	16	15	93.8
Departments of Medicine	24	20	83.3	-	-	-	24	20	83.3
Institution R&D Size Class[1]									
1 (largest)	132	123	93.2	76	75	98.7	56	48	85.7
2	98	93	94.9	53	50	94.3	45	43	95.6
3	96	94	97.9	49	49	100.0	47	45	95.7
4 (smallest)	61	57	93.4	17	16	94.1	44	41	93.2
Institution Control									
Private	134	121	90.3	44	43	97.7	90	78	86.7
Public	253	246	97.2	151	147	97.4	102	99	97.1

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[1] Graduate school classification based on FY 1980 R&D expenditures in all fields encompassed by survey; medical school classification based on FY 1982 NIH extramural awards. In both cases, all institutions in the survey universe were ranked from largest to smallest in R&D expenditures/awards and were then divided into quartiles based on cumulative R&D. Category 1 contains sampled institutions from the top quartile.

2.4.3 Instrument Data Sheet

Faculty researchers returned completed Instrument Data Sheets for 4,397 instruments, constituting 97 percent of the 4,555 instruments in the equipment sample (see Table 2-4). As would be expected with an overall response rate this high, no differences worth noting were found by type of department, size of R&D expenditures, institution control, cost of equipment, or age of equipment.

In Table 2-5 an analysis of the Instrument Data Sheet returns is shown by status, or classification as to eligibility for inclusion in the study. Of the 4,555 instruments for which Instrument Data Sheets were forwarded, 3,358 were found to be actively in research use. Another set of 582 instruments were found to be either inactive or inoperable throughout the year, or not yet placed into service. These two sets of instruments, numbering 3,940 or 83.5 percent of the sample, constituted the national stock that formed the basis for the analysis. An additional 457 instruments were classified as out of scope for this study for a variety of reasons. No response was received for 158 instruments. Refusals accounted for 90 of these nonresponses. For the remaining 68, no knowledgeable person could be found to answer the detailed questions asked about the instrument, e.g., the principal investigator was absent from the institution and no one else was familiar with the instrument.

2.4.4 Questionnaire Item Response

Most questionnaire items had response rates close to 100 percent. For this reason, in most of the tables in the body of this report, it did not seem worthwhile to present a category labeled "not ascertained." Such a category would usually have

Table 2-4. Equipment survey response rates: Biological and Medical Sciences

Characteristics	Total equipment/items			Graduate school equipment/items			Medical school equipment/items		
	Sample	Response	Rate	Sample	Response	Rate	Sample	Response	Rate
Total, all department/facilities	4555	4397	96.5	1984	1918	96.7	2571	2479	96.4
Departments									
Biological sciences, total	4110	3977	96.8	1984	1918	96.7	2126	2059	96.8
Biochemistry	600	575	95.8	285	269	94.4	315	306	97.1
Microbiology	387	370	95.6	158	158	100.0	229	212	92.6
Molecular/Cellular biology	319	296	92.8	156	140	89.7	163	156	95.7
Physiology/Biophysics	419	403	96.2	99	93	93.9	320	310	96.9
Anatomy	253	249	98.4	21	21	100.0	232	228	98.3
Pathology	377	376	99.7	37	37	100.0	340	339	99.7
Pharmacology/Toxicology	341	328	96.2	45	45	100.0	296	283	95.6
Zoology/Entomology	231	225	97.4	193	192	99.5	38	33	86.8
Botany	172	163	94.8	172	163	94.8	-	-	-
Food and Nutrition	196	191	97.4	196	191	97.4	-	-	-
Biology, general and n.e.c.	815	801	98.3	622	609	97.9	193	192	99.5
Departments of Medicine	445	420	94.4	-	-		445	420	94.4
Institution R&D Size Class[1]									
1 (largest)	1640	1574	96.0	891	870	97.6	749	704	94.0
2	1305	1247	95.6	578	543	93.9	727	704	96.8
3	1025	1000	97.6	421	413	98.1	604	587	97.2
4 (smallest)	585	576	98.5	94	92	97.9	491	484	98.6
Institution Control									
Private	1711	1634	95.5	518	495	95.6	1193	1139	95.5
Public	2844	2763	97.2	1466	1423	97.1	1378	1340	97.2
Item Cost Range									
$10,000 - $49,999	3913	3787	96.8	1781	1734	97.4	2132	2053	96.3
$50,000 - $99,999	452	427	94.5	149	135	90.6	303	292	96.4
$100,000 - $999,999	190	183	96.3	54	49	90.7	136	134	98.5
Item Age									
1-5 years (1979-83)	1957	1895	96.8	902	878	97.3	1055	1017	96.4
6-10 years (1974-78)	1392	1288	96.9	526	506	96.2	803	782	97.4
11 years or more (1973 or before)	1220	1174	96.2	535	515	96.3	685	659	96.2
Not ascertained	49	40	81.6	21	19	90.5	28	21	75.0

[1] Graduate school classification based on FY 1980 R&D expenditures in all fields encompassed by survey; medical school classification based on FY 1982 NIH extramural awards. In both cases, all institutions in the survey universe were ranked from largest to smallest in R&D expenditures/awards and were then divided into quartiles based on cumulative R&D. Category 1 contains sampled institutions from the top quartile.

Table 2-5. Status of sampled equipment items: Biological and Medical Sciences

Item response status	Total		Graduate schools		Medical schools	
	No.	Percent	No.	Percent	No.	Percent
Total, all sampled items	4555	100.0	1984	100.0	2571	100.0
Instrument/system in research use	3358	73.7	1516	76.4	1842	71.6
Other items in national stock, total	582	12.8	237	12.0	345	13.4
Not yet in use	25	0.5	11	0.6	14	0.5
No longer in use: inactive or inoperable through 1983	557	12.2	226	11.4	331	12.9
Out-of-scope, total	457	10.0	165	8.3	292	11.4
No longer present -- sold, scrapped, traded-in, cannibalized, etc.	179	3.9	67	3.4	112	4.4
Not research equipment -- teaching, office, etc.[1]	170	3.7	61	3.1	109	4.2
Dedicated accessory of instrument/system in research use[2]	46	1.0	14	0.7	32	1.2
Other, e.g., cost out of range, duplicate listing	62	1.4	23	1.2	39	1.5
Nonresponse, total	158	3.5	66	3.3	92	3.6
Refusal	90	2.0	43	2.2	47	1.8
Other[3]	68	1.5	23	1.2	45	1.8

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[1] To the extent possible, items in this category were edited from institution equipment listings prior to sampling. Otherwise, the number and percent of such items would have been larger.

[2] Information about accessories is contained in the data record for the principal instrument or component of the system.

[3] Other nonresponse was due principally to unavailability of person knowledgeable about the instrument -- ill, on sabbatical, etc.

contained less than 2 percent of all responses. Consequently, however, different tables dealing with the same basic data (such as the estimated total number of instrument systems or the estimated total cost of equipment) may show slightly different totals.

2.4.5 Summary Statement on Response

The exceptionally high response rates obtained in this study suggest that the major topic of the survey -- the adequacy of academic research equipment in the biological and medical sciences -- is a matter of widespread interest and concern at all levels of the academic research community, from central administration to front-line principal investigators. Response rates of the same magnitude were also obtained in Phase I of the study.

2.5 Data Collection for Departments of Medicine

One objective of the study was to assess the feasibility of applying the survey methodology to the medical (clinical) sciences in medical schools. From Table 2-4, it appears that instrument data could be obtained from departments of medicine at about the same level of response as was achieved from departments in the biological sciences at medical schools.

However, departments of medicine had more difficulty with the Department/Facility Questionnaire. Four of the 24 departments of medicine in the medical school sample did not respond to that questionnaire (Table 2-3). It was learned from the institution coordinators that the difficulty lay with the structure of these departments. In at least some medical schools, departments of medicine are larger and more diverse than most departments in the biological sciences. The several clinical divisions or units that constitute departments of medicine in those instances operate with relative independence. Information about equipment expenditures, funding sources, etc., is often not maintained for the department of medicine as a whole. Also, judgments on major departmental needs and priorities become too difficult when so many diverse interests are involved. While the response to the Department/Facilities Questionnaire was a "respectable" 83 percent among departments of medicine, the problem of one person responding for a number of diverse clinical fields suggests that it might be better, when seeking instrumentation information for specific clinical sciences, to ask each clinical division or unit head directly.

All things considered, however, the conclusion is that it is feasible to obtain data on the clinical sciences with the survey methodology used for this study. The data actually obtained in the current survey of departments of medicine, while not easily interpreted in terms of fields or subfields of science, were obtained from a nationally representative sample of such departments. In this report, these sample data have been aggregated to produce national estimates for departments of medicine in the same way that all other survey data were treated.

2.6 Treatment of Data

Discussion of the study results is organized around specific tables, each table being based on an item in one of the two survey questionnaires. Most of these tables follow the same format. In general, responses to questions on the survey questionnaires are broken out by department type (in the case of data from the Department/Facilities Questionnaire) or by subfield of research (in the case of data from the Instrument Data Sheet). These breakdowns typically are followed by two sets of summary groupings: (1) field and setting, which separates biological sciences from the medical schools' departments of medicine, and also divides biological sciences into graduate (nonmedical) schools and medical schools; and (2) institution control, which separates private from public institutions.

It has already been noted that the tables in subsequent chapters report results in the form of national estimates, statistically weighted to represent all departments in the survey universe. Typically, estimates are rounded to a level of precision judged appropriate for the particular table (e.g., percentages in integers, dollars in thousands). Because each estimate is rounded individually, numbers and percentages may not sum exactly to the totals shown in a given table.

This analysis of the biological and medical sciences is part of a study of larger scope which includes all fields in the physical and life sciences, engineering, and computer sciences. As a result, it is possible to place the biological sciences in perspective with the other sciences. A few such comparison tables are included in Appendix A of this report. Relevant comparisons are discussed in the body of the report with references made to the appropriate appendix tables.

3. NEEDS AND PRIORITIES FOR RESEARCH EQUIPMENT: ASSESSMENT BY DEPARTMENT HEADS

A stratified probability sample of 367 biological and medical science department heads provided an overview of the condition of their research instrumentation for this study. The selected department heads represented over 1,200 departments and research facilities at institutions conducting 95 percent of the nation's academic research in the biological and medical sciences. The assessments made by these department heads constitute a significant front-line view of the current stock of instrumentation, the scope of maintenance and repair activities within departments, and the nature of the most pressing needs for new or replacement equipment.

3.1 Adequacy of Current Instrumentation

A set of questions was asked of department/facility heads relating to adequacy of the instrumentation in place during 1983. In reply to a question on whether there were important subject areas in which critical scientific experiments could not be conducted in 1983 because needed equipment was lacking, 58 percent of the departments/facilities responded in the affirmative. (See Table 3-1.) The percentages ranged from only 27 percent in molecular/cellular biology to about 75 percent for botany and general biology and 87 percent for food/nutrition. This problem existed in 59 percent of the biological sciences departments, compared to 41 percent of the departments of medicine. A large difference appears for institution control, with only 42 percent of departments in private institutions reporting such a deficiency, compared to 65 percent of those in public institutions.

TABLE 3-1
DEPARTMENTS/FACILITIES REPORTING IMPORTANT AREAS IN WHICH CRITICAL EXPERIMENTS CANNOT BE PERFORMED DUE TO LACK OF NEEDED EQUIPMENT: BIOLOGICAL AND MEDICAL SCIENCES

	NUMBER OF DEPARTMENTS/FACILITIES	PERCENT REPORTING INABILITY TO CONDUCT CRITICAL EXPERIMENTS DUE TO LACK OF NEEDED EQUIPMENT
TOTAL	1219	58
DEPARTMENTS		
BIOCHEMISTRY	144	42
MICROBIOLOGY	151	50
MOLECULAR/CELLULAR BIOLOGY	74	27
PHYSIOLOGY/BIOPHYSICS	132	56
ANATOMY	82	60
PATHOLOGY	88	62
PHARMACOLOGY/TOXICOLOGY	104	60
ZOOLOGY/ENTOMOLOGY	69	69
BOTANY	33	76
FOOD AND NUTRITION	51	87
BIOLOGY, GENERAL AND N.E.C.	210	75
DEPARTMENTS OF MEDICINE	81	41
FIELD AND SETTING		
BIOLOGICAL SCIENCES, TOTAL	1138	59
GRADUATE SCHOOLS	550	60
MEDICAL SCHOOLS	588	58
DEPARTMENTS OF MEDICINE	81	41
INSTITUTION CONTROL		
PRIVATE	379	42
PUBLIC	840	65

Relative to other fields of science, departments in the biological sciences reported less frequently that they were unable to perform critical experiments. Comparison Table A-1 in Appendix A reveals that about 90 percent of departments in the physical sciences and engineering, and 95 percent of those in the computer sciences, reportedly lacked the equipment needed for frontier experiments -- in contrast to 59 percent for the biological sciences.

When asked to rate the adequacy of available research instrumentation for tenured and untenured faculty-level researchers (Table 3-2), department heads described the current stock of equipment as excellent for tenured faculty in only 16 percent of the departments, and for untenured faculty in 15 percent. It was considered insufficient in 27 and 33 percents of the departments respectively. Once more, there were large differences by department type, with molecular/cellular biology departments considering themselves better equipped than any other discipline. Botany and food/nutrition again had the largest proportion of departments reporting insufficient instrumentation, particularly for untenured researchers.

Biological science departments in medical schools were far less likely to report insufficient equipment (15% to 38% for tenured faculty) than were similar departments in graduate schools. There was also a large difference in response to this question in favor of private institutions, with 36 percent of private school departments considering their equipment excellent. Only seven percent of the public institutions considered their equipment excellent.

Comparing the biological sciences with other fields of science (Appendix Table A-2) again indicates that, for tenured faculty, biology has a more favorable assessment of existing

TABLE 3-8
DEPARTMENT/FACILITY ASSESSMENT OF ADEQUACY OF AVAILABLE RESEARCH INSTRUMENTATION
BIOLOGICAL AND MEDICAL SCIENCES

	PERCENT OF DEPARTMENTS/FACILITIES ASSESSING INSTRUMENTATION AVAILABLE TO TENURED FACULTY AND EQUIVALENT P.I.s AS:				PERCENT OF DEPARTMENTS/FACILITIES ASSESSING INSTRUMENTATION AVAILABLE TO UNTENURED FACULTY AND EQUIVALENT P.I.s AS:			
	TOTAL	EXCELLENT	ADEQUATE	INSUFFICIENT	TOTAL	EXCELLENT	ADEQUATE	INSUFFICIENT
TOTAL	100	16	57	27	100	15	52	33
DEPARTMENTS								
BIOCHEMISTRY	100	25	61	14	100	27	56	17
MICROBIOLOGY	100	16	42	42	100	17	31	52
MOLECULAR/CELLULAR BIOLOGY	100	40	51	9	100	40	49	11
PHYSIOLOGY/BIOPHYSICS	100	25	57	18	100	31	51	18
ANATOMY	100	11	67	22	100	0	78	22
PATHOLOGY	100	14	75	11	100	8	67	25
PHARMACOLOGY/TOXICOLOGY	100	7	78	15	100	0	78	22
ZOOLOGY/ENTOMOLOGY	100	7	48	45	100	7	34	59
BOTANY	100	14	19	67	100	14	18	68
FOOD AND NUTRITION	100	0	44	56	100	4	24	72
BIOLOGY, GENERAL AND N.E.C.	100	4	69	27	100	7	65	28
DEPARTMENTS OF MEDICINE	100	24	41	35	100	20	33	47
FIELD AND SETTING								
BIOLOGICAL SCIENCES, TOTAL	100	15	59	26	100	15	53	32
GRADUATE SCHOOLS	100	14	48	38	100	15	42	43
MEDICAL SCHOOLS	100	16	69	15	100	15	63	22
DEPARTMENTS OF MEDICINE	100	24	41	35	100	20	33	47
INSTITUTION CONTROL								
PRIVATE	100	36	53	11	100	37	46	17
PUBLIC	100	7	59	34	100	6	54	40

research equipment than any other field except materials science. The lower percentage of insufficient instrumentation for biological sciences as a whole, however, can be traced to the particularly low proportion of medical school departments giving this rating. Biological science departments located in graduate schools show much closer agreement with departments in the physical sciences, engineering, and computer science when reporting insufficient instrumentation.

3.2 Priorities for Increased Federal Support

Department/facility heads were asked to choose how they would allocate increased Federal funding for research equipment from the viewpoint of investigators in their departments/facilities. Each head was asked to select one of four options. Table 3-3 presents their choices. Overall, two-thirds of department heads in the biological sciences and departments of medicine identified instrument systems in the $10,000 to $50,000 cost range as the top priority need for their departments. Another 20 percent selected systems costing between $50,000 and $1,000,000. Only 12 percent recommended increased funding for equipment under $10,000, and not a single department/facility head chose large scale facilities costing over $1,000,000. This pattern of recommendations is a strong validation for the decision to confine the present study to equipment in the cost range of $10,000 to $1,000,000.

Differences among disciplines are complex. Chairpersons in departments of microbiology, pathology, and botany, showed a statistically "normal" distribution of needs ranging across all three cost categories, while 90 percent of the pharmacology departments' priority needs were concentrated in the middle cost range. Molecular/cellular biology had the largest

TABLE 3-3
DEPARTMENT/FACILITY RECOMMENDATIONS FOR INCREASED FEDERAL SUPPORT FOR RESEARCH INSTRUMENTATION
BIOLOGICAL AND MEDICAL SCIENCES

	PERCENT OF DEPARTMENTS/FACILITIES RECOMMENDING AS TOP PRIORITY AREA FOR INCREASED FEDERAL SUPPORT OF ACADEMIC RESEARCH EQUIPMENT[1]					
	TOTAL	LARGE SCALE FACILITIES	SYSTEMS IN \$50,000-\$1 MILLION RANGE	SYSTEMS IN \$10,000-\$50,000 RANGE	LAB EQUIPMENT UNDER \$10,000	OTHER
TOTAL	100	0	20	66	12	2
DEPARTMENTS						
BIOCHEMISTRY	100	0	24	59	8	9
MICROBIOLOGY	100	0	20	55	25	0
MOLECULAR/CELLULAR BIOLOGY	100	0	31	54	15	0
PHYSIOLOGY/BIOPHYSICS	100	0	17	81	2	0
ANATOMY	100	0	17	76	7	0
PATHOLOGY	100	0	24	56	20	0
PHARMACOLOGY/TOXICOLOGY	100	0	8	90	2	0
ZOOLOGY/ENTOMOLOGY	100	0	5	70	25	0
BOTANY	100	0	25	49	26	0
FOOD AND NUTRITION	100	0	15	74	7	4
BIOLOGY, GENERAL AND N.E.C.	100	0	22	64	11	3
DEPARTMENTS OF MEDICINE	100	0	28	72	0	0
FIELD AND SETTING						
BIOLOGICAL SCIENCES, TOTAL	100	0	19	66	12	3
GRADUATE SCHOOLS	100	0	21	63	15	1
MEDICAL SCHOOLS	100	0	19	69	10	2
DEPARTMENTS OF MEDICINE	100	0	28	72	0	0
INSTITUTION CONTROL						
PRIVATE	100	0	29	57	13	1
PUBLIC	100	0	16	71	11	2

proportion (31%) needing comparatively expensive ($50,000 to $1,000,000) systems. Private institutions reported needs for systems in the $50,000 to $1,000,000 range more often than did the public institutions (29% to 16%).

Most fields of science indicated a need for more expensive equipment than was reported in the biological sciences (Appendix Table A-3). While 20 percent of departments in the biological sciences professed a need for systems in the $50,000 to $1,000,000 cost range, 36 percent of those in the environmental sciences and 43 percent in the physical sciences reported needing equipment in that price range. Conversely, the biological sciences and agriculture were the only fields with an appreciable number of departments describing their top priority as laboratory equipment costing less than $10,000.

3.3 Types of Instrumentation Most Urgently Needed

Department/facility heads were asked to list up to three pieces of research equipment costing between $10,000 and $1 million that were most urgently needed. They were also asked to indicate the approximate cost of each piece of equipment. Responses were classified according to a typology developed for this study by a team of NIH scientists,[10] and they were then statistically weighted to reflect all biological science and medicine departments represented by responding departments in the sample. Table 3-4 shows the resulting response frequencies for each instrument type. It also presents the mean and median costs for each instrument type. Perhaps the most striking finding in this table is that the research instruments most urgently

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[10] W. Sue Badman, Ph.D., Marvin Cassman, Ph.D., and Rachel Levinson developed the study typology.

TABLE 3-4
NUMBER OF REQUESTS AND AVERAGE COST OF RESEARCH INSTRUMENTS MOST URGENTLY NEEDED IN ACADEMIC SETTINGS, BY TYPE OF INSTRUMENT: BIOLOGICAL AND MEDICAL SCIENCES [1]

	NUMBER OF REQUESTS	---ESTIMATED COST--- MEAN	MEDIAN
TOTAL, ALL TYPES	3203	$87,500	$40,000
INSTRUMENT TYPE			
PREPARATIVE (e.g., CENTRIFUGES, SCINTILLATION COUNTERS, INCUBATORS)	1030	43,900	29,500
DNA ANALYZERS-SYNTHESIZERS	367	84,100	71,000
ELECTRON MICROSCOPY (EM)	359	190,100	145,000
GENERAL SPECTROSCOPY	283	38,600	25,000
HIGH PRESSURE LIQUID CHROMATOGRAPHY (HPLC)	291	31,000	26,500
COMPUTERS	150	89,500	45,000
NUCLEAR MAGNETIC RESONANCE (NMR)	111	316,700	250,000
LIGHT MICROSCOPY	128	61,100	29,000
CELL SORTERS	124	158,900	140,000
MASS SPECTROSCOPY (MS)	81	178,300	90,000
IMAGE ANALYZERS	77	77,500	38,000
X-RAY	25	184,800	95,000
CLINICAL DEVICES [2]	25	134,000	20,000
MISCELLANEOUS	152	38,000	30,000

[1] DATA ARE NATIONAL ESTIMATES BASED ON LISTINGS OF UP TO THREE TOP-PRIORITY NEEDS, AS REPORTED BY THE STUDY SAMPLE OF 367 DEPARTMENTS. TOTAL NUMBER OF REQUESTS IS 927.

[2] SAMPLE CONSISTS OF ONLY SEVEN ITEMS, ONE OF WHICH HAD AN UNUSUALLY HIGH COST.

needed in the biological sciences and departments of medicine are, for the most part, comparatively inexpensive. Even though cost was not a factor as department heads constructed their "wish lists," the overall median cost of most urgently needed instruments was only $40,000. The most frequently cited type of needed equipment, "preparative instruments," had a median cost of only $29,500. "Big-ticket" items, those with a median cost above $100,000, were mentioned comparatively infrequently: electron microscopes (359 of 3,203 mentions), cell sorters (124 mentions), and NMR spectrometers (111 mentions).

Departments varied considerably in the level of cost of the equipment on their "wish lists." (See Table 3-5.) For departments of microbiology, physiology/biophysics, pharmacology/toxicology, and food/nutrition, 70 percent or more of the top priority instruments cost less than $60,000. For departments of anatomy and medicine, on the other hand, about 50 percent cost more than $60,000.

Table 3-6 shows the types of research instruments needed most by departments in different fields. For this analysis, the 14 types of equipment were consolidated into 7 categories by combining instrument types with similar functions. The HPLC and preparatory instrument category, which had the least expensive and the greatest number of items listed, was especially prevalent for departments of microbiology (50 percent of all items identified) and pharmacology/toxicology (52 percent). Most types of departments had a peak frequency in this category, but also had secondary peaks in other categories unique to the discipline represented by the department. Departments of anatomy were an exception, with a peak (38 percent of the top priority equipment) in the relatively costly category of electron microscopy.

TABLE 3-5
DISTRIBUTION OF ESTIMATED COSTS FOR MOST URGENTLY NEEDED RESEARCH INSTRUMENTS, BY DEPARTMENT:
BIOLOGICAL AND MEDICAL SCIENCES [1]

		INSTRUMENT COST RANGE					
	TOTAL	$10,000- $20,000	$21,000- $40,000	$41,000- $60,000	$61,000- $100,000	$101,000- $200,000	$201,000- AND OVER
TOTAL	3203 100%	590 18%	1065 33%	422 13%	434 14%	362 11%	329 10%
DEPARTMENTS							
BIOCHEMISTRY	366 100%	65 18%	113 31%	44 12%	78 21%	31 8%	36 10%
MICROBIOLOGY	441 100%	69 16%	183 41%	68 15%	70 16%	36 8%	16 4%
MOLECULAR/CELLULAR BIOLOGY	167 100%	42 25%	48 29%	9 6%	22 13%	34 20%	13 8%
PHYSIOLOGY/BIOPHYSICS	324 100%	38 12%	144 44%	44 14%	23 7%	35 11%	40 12%
ANATOMY	223 100%	24 11%	62 28%	24 11%	43 19%	16 7%	55 25%
PATHOLOGY	230 100%	26 11%	92 40%	20 9%	20 9%	48 21%	25 11%
PHARMACOLOGY/TOXICOLOGY	296 100%	52 18%	148 50%	21 7%	34 11%	21 7%	22 7%
ZOOLOGY/ENTOMOLOGY	163 100%	61 38%	20 12%	26 16%	23 14%	15 9%	17 10%
BOTANY	100 100%	8 8%	38 38%	22 22%	10 10%	8 8%	14 14%
FOOD AND NUTRITION	126 100%	36 29%	34 27%	28 23%	20 16%	7 6%	0 0%
BIOLOGY, GENERAL AND N.E.C.	594 100%	142 24%	143 24%	91 15%	62 10%	99 17%	57 10%
DEPARTMENTS OF MEDICINE	172 100%	27 15%	42 24%	25 14%	30 17%	13 8%	35 21%

[1] DATA ARE NATIONAL ESTIMATES BASED ON LISTINGS OF UP TO THREE TOP-PRIORITY NEEDS, AS REPORTED BY THE STUDY SAMPLE OF 367 DEPARTMENTS. TOTAL NUMBER OF REQUESTS IN THE SAMPLE IS 927.

TABLE 3-6
TYPES OF RESEARCH INSTRUMENTS MOST URGENTLY NEEDED, BY DEPARTMENT: BIOLOGICAL AND MEDICAL SCIENCES [1]

	TOTAL	COMPUTERS AND IMAGE ANALYZERS	EM AND LIGHT MICROSCOPY	HPLC AND PREPARATIVE	NMR AND GENERAL SPECTROSCOPY	MS AND ANALYZERS-SYNTHESIZERS	X-RAY	CLINICAL AND CELL SORTERS AND MISC.
TOTAL	3203 100%	227 7%	487 15%	1322 41%	394 12%	448 14%	25 1%	301 9%
DEPARTMENTS								
BIOCHEMISTRY	366 100%	13 4%	7 2%	177 48%	54 15%	95 26%	5 1%	14 4%
MICROBIOLOGY	441 100%	44 10%	57 13%	220 50%	35 8%	47 11%	0 0%	38 9%
MOLECULAR/CELLULAR BIOLOGY	167 100%	3 2%	24 14%	61 37%	16 10%	46 28%	3 2%	13 8%
PHYSIOLOGY/BIOPHYSICS	324 100%	38 12%	40 12%	125 39%	29 9%	12 4%	5 2%	75 23%
ANATOMY	223 100%	41 18%	85 38%	49 22%	19 9%	13 6%	5 2%	13 6%
PATHOLOGY	230 100%	5 2%	78 34%	88 38%	21 9%	20 9%	0 0%	18 8%
PHARMACOLOGY/TOXICOLOGY	296 100%	35 12%	8 3%	154 52%	35 12%	43 15%	0 0%	21 7%
ZOOLOGY/ENTOMOLOGY	163 100%	16 10%	43 26%	63 39%	9 6%	11 7%	2 1%	20 12%
BOTANY	100 100%	2 2%	17 17%	47 47%	18 18%	5 5%	0 0%	11 11%
FOOD AND NUTRITION	126 100%	2 2%	7 6%	50 40%	43 34%	13 10%	0 0%	11 9%
BIOLOGY, GENERAL AND N.E.C.	594 100%	19 3%	104 18%	235 40%	100 17%	89 15%	5 1%	42 7%
DEPARTMENTS OF MEDICINE	172 100%	11 6%	16 9%	54 31%	13 8%	55 32%	0 0%	25 15%

[1] DATA ARE NATIONAL ESTIMATES BASED ON LISTINGS OF UP TO THREE TOP-PRIORITY NEEDS, AS REPORTED BY THE STUDY SAMPLE OF 367 DEPARTMENTS. TOTAL NUMBER OF REQUESTS IN THE SAMPLE IS 927.

3.4 Summary

Department heads in the biological sciences and in departments of medicine varied by discipline in the degree to which they considered presently available equipment adequate for current research needs. Overall, over half reported that critical experiments in their disciplines could not be performed because suitable instrumentation was not available. While about one-fourth of all departments considered their instrumentation for tenured faculty researchers to be insufficient, in some disciplines the percentage was much higher. A larger proportion of insufficient instrumentation was reported for nontenured researchers. On both of these adequacy parameters, private institutions reported more favorable conditions than public institutions, by wide margins.

There was a marked need in the biological and medical sciences for upgrading/expansion of equipment in the $10,000 to $50,000 cost range, with some disciplines also expressing a need for more expensive items ranging from $50,000 to $1,000,000.

Compared to those in other fields, biological science departments appeared to judge themselves as less severely impaired by lack of equipment needed to perform critical experiments and by insufficient instrumentation for investigators to conduct research in their major interests. In the latter instance, however, only the medical schools had this advantage, for biology departments in the graduate schools closely resembled departments in other graduate school fields on the degree of perceived insufficiency of current instrumentation. Concerning priority needs for equipment in different cost ranges (when compared to other fields of science), the biological sciences in both graduate and medical schools were more likely to need systems in the $10,000 to $50,000 category. They were correspondingly less likely to need instrumentation costing more than that.

The types of research equipment that were most needed, according to department heads, were predominantly below $75,000 in cost, although there was considerable variation among departments on cost distribution. The most common need across departments was for instruments in the preparative or HPLC category, and these were the least costly of the needed instrument types. The remainder of their instrument needs were unique to each department.

4. EXPENDITURES FOR RESEARCH EQUIPMENT, FY 1983

Current expenditures for scientific research equipment are one indicator of the economic well-being of the scientific enterprise. Analyzing expenditures by appropriate units -- dollars spent per faculty-level researcher, and per institution -- permits comparisons of relative funding among various groups of institutions and other areas of interest. When comparable data are obtained for future years, trends in expenditure rates can be monitored.

4.1 Department Expenditures for Instrumentation

Table 4-1 presents information on FY 1983 department/facility instrumentation-related expenditures in three categories: (1) purchase of research equipment costing $500 or more; (2) purchase of research-related computer services, where separate charges are incurred for this purpose; and (3) maintenance and repair of research equipment. Nearly three-fourths of all instrumentation-related expenditures are used to purchase equipment, with the rest being almost evenly divided between the cost of purchased computer services and maintenance and repair expenses. The greatest variation among departments occurs in the percentage of total instrumentation expenditures for purchases of computer services. Several types of departments are much heavier purchasers of computer services than others. Aside from any computers used within the departments that do not practice separate billing, departments of molecular/cellular biology spent 27 percent of their instrumentation funds for services from institutional or other computing facilities. A similar proportion was spent by food/nutrition, and almost as much by pathology. Departments of anatomy, biochemistry, and microbiology were the least likely to purchase computer services from outside the departments.

TABLE 4-1
INSTRUMENTATION-RELATED EXPENDITURES IN FY 1983
ACADEMIC DEPARTMENTS AND FACILITIES: BIOLOGICAL AND MEDICAL SCIENCES

(DOLLARS IN MILLIONS)

	-----FY 1983 EXPENDITURES AND PERCENT OF EXPENDITURES------			
	TOTAL	PURCHASE OF RESEARCH EQUIPMENT $500 OR MORE	PURCHASE OF RESEARCH-RELATED COMPUTER SERVICES	MAINTENANCE/ REPAIR OF RESEARCH EQUIPMENT
TOTAL	$223.8 100%	$158.2 71%	$29.9 13%	$35.7 16%
DEPARTMENTS				
BIOCHEMISTRY	24.4 100%	19.1 78%	1.1 5%	4.3 17%
MICROBIOLOGY	13.8 100%	10.7 78%	.4 3%	2.6 19%
MOLECULAR/CELLULAR BIOLOGY	28.9 100%	18.4 64%	7.9 27%	2.6 9%
PHYSIOLOGY/BIOPHYSICS	24.9 100%	17.8 71%	2.7 11%	4.4 18%
ANATOMY	12.7 100%	9.7 77%	.3 2%	2.6 21%
PATHOLOGY	13.1 100%	8.0 61%	2.7 21%	2.4 18%
PHARMACOLOGY/TOXICOLOGY	18.8 100%	13.3 71%	2.7 14%	2.8 15%
ZOOLOGY/ENTOMOLOGY	7.0 100%	4.9 70%	.8 11%	1.3 18%
BOTANY	3.9 100%	3.0 77%	.3 7%	.6 16%
FOOD AND NUTRITION	6.1 100%	3.8 62%	1.5 25%	.8 14%
BIOLOGY, GENERAL AND N.E.C.	38.7 100%	23.6 61%	7.3 19%	7.7 20%
DEPARTMENTS OF MEDICINE	31.4 100%	25.9 82%	2.1 7%	3.5 11%
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	192.3 100%	132.4 69%	27.8 14%	32.2 17%
GRADUATE SCHOOLS	79.0 100%	51.8 66%	13.2 17%	14.0 18%
MEDICAL SCHOOLS	113.3 100%	80.5 71%	14.5 13%	18.3 16%
DEPARTMENTS OF MEDICINE	31.4 100%	25.9 82%	2.1 7%	3.5 11%
INSTITUTION CONTROL				
PRIVATE	100.6 100%	69.2 69%	16.8 17%	14.5 14%
PUBLIC	123.1 100%	89.0 72%	13.0 11%	21.1 17%

Amounting to one-sixth of total instrumentation expenditures in 1983, funds spent for equipment maintenance and repair were an important component of the total investment in instrumentation. These expenditures are well worth tracking over time to detect trends and any relationship to equipment performance.

In the field and setting breakout, departments of medicine spent a much smaller proportion of their instrumentation funds on computer services and maintenance than did biological science departments located in either graduate or medical schools. There were no noteworthy differences between private and public institutions.

4.2 Equipment Expenditures per Research Investigator and per Institution

Department/facility heads were also asked how many faculty-level researchers were employed in their departments that year. Table 4-2 presents, by department type, survey findings concerning numbers of faculty-level researchers, the dollars spent on research equipment (previously shown in Table 4-1), and the unit values -- dollars spent in 1983 per faculty-level researcher and per institution.

A cautionary note: the only source used for numbers of faculty and research equipment expenditures in FY 1983 was information provided by departments. While the department is usually the principal base for research in a discipline, many of the members of a department may be engaged in research in subfields outside that discipline. For example, some members of a department of microbiology may actually be engaged in research in the subfields of biochemistry or molecular biology. Therefore,

TABLE 4-E
RESEARCH EQUIPMENT EXPENDITURES IN FY 1983 PER FACULTY RESEARCHER AND INSTITUTION
ACADEMIC DEPARTMENTS AND FACILITIES: BIOLOGICAL AND MEDICAL SCIENCES

(DOLLARS IN THOUSANDS)

		-EXPENDITURES PER PERSON AND INSTITUTION-			
		FACULTY-LEVEL RESEARCHERS (1)		INSTITUTIONS	
	FY 1983 EQUIP. EXP.	NUMBER	EXP. PER PERSON	NUMBER	EXP. PER INST.
TOTAL	$158,200	26,635	$5.9	249	$635.3
DEPARTMENTS					
BIOCHEMISTRY	19,100	2,216	8.6	- [2]	-
MICROBIOLOGY	10,700	2,187	4.9	-	-
MOLECULAR/CELLULAR BIOLOGY	18,400	843	21.8	-	-
PHYSIOLOGY/BIOPHYSICS	17,800	2,446	7.3	-	-
ANATOMY	9,700	1,514	6.4	-	-
PATHOLOGY	8,000	2,041	3.9	-	-
PHARMACOLOGY/TOXICOLOGY	13,300	1,799	7.4	-	-
ZOOLOGY/ENTOMOLOGY	4,900	1,215	4.0	-	-
BOTANY	3,000	752	4.0	-	-
FOOD AND NUTRITION	3,800	730	5.2	-	-
BIOLOGY, GENERAL AND N.E.C.	23,600	4,505	5.2	-	-
DEPARTMENTS OF MEDICINE	25,900	6,386	4.1	-	-
FIELD AND SETTING					
BIOLOGICAL SCIENCES, TOTAL	132,300	20,248	6.5	249	531.3
GRADUATE SCHOOLS	51,800	9,654	5.4	157	330.3
MEDICAL SCHOOLS	80,500	10,594	7.6	92	875.0
DEPARTMENTS OF MEDICINE	25,900	6,386	4.1	92	281.5
INSTITUTION CONTROL					
PRIVATE	69,200	8,366	8.3	93	744.1
PUBLIC	89,000	18,268	4.9	156	570.5

[1] NUMBER OF FACULTY AND EQUIVALENT NON-FACULTY RESEARCHERS (FULL-TIME AND PART-TIME) WHO PARTICIPATE IN ONGOING RESEARCH PROJECTS AND WHO ARE MEMBERS OF THE DEPARTMENTS OF THE GRADUATE AND MEDICAL SCHOOLS IN THE SURVEY UNIVERSE, AS REPORTED BY DEPARTMENT HEADS.

[2] SINCE SOME KINDS OF DEPARTMENTS EXIST LARGELY EITHER IN MEDICAL SCHOOLS OR OUTSIDE MEDICAL SCHOOLS, NO SINGLE DENOMINATOR WOULD BE APPROPRIATE.

the numbers given within departments for researchers and equipment expenditures do not necessarily indicate the figures applicable to the various subfields of research.

With this reservation, it is still useful to examine indicators of relative funding for research equipment in different types of departments. Overall, FY 1983 expenditures were $5,900 per faculty-level researcher. Except for molecular/cellular biology, which had an extraordinary level of expenditures of $21,800 per researcher, the expenditure ratio among departments ranged from $3,900 for pathology to $8,600 for biochemistry.

The larger institution-level groupings in Table 4-2 eliminate the interpretive ambiguities noted for the department-level statistics, since assuming the expenditures and numbers of researchers for all departments is equivalent to the summations for all subfields of research. For FY 1983, the research equipment expenditures per researcher in the biological sciences exceeded by a large amount those of departments of medicine: $6,500 to $4,100 per person. It was also observed that the 92 departments of medicine had an average of 69.4 faculty-level researchers per department, larger than the average per department of 21.2 for all 1,255 departments represented in the study. In the clinical fields, physician/researchers must allocate their time to patient care and residency teaching as well as research. This may contribute to a research environment in departments of medicine that is not comparable to that in the biological sciences.

Excluding departments of medicine, medical schools had nearly twice as many researchers per institution as graduate schools, 115.2 to 61.5, and medical schools outspent graduate schools by $7,600 to $5,400 on new research equipment in FY 1983 per researcher. Medical schools also had nearly twice as many researchers per institution as graduate schools, 115.2 to 61.5. Per institution, medical schools spent about two and a half times as much as graduate schools for research equipment in FY 1983.

Private schools spent nearly twice as much for research equipment per researcher as public institutions. Expenditures per institution for private schools were $744,100, compared to $570,500 for public institutions.

4.3 Summary

In the biological sciences and in departments of medicine, instrumentation-related expenditures accounted for about $223 million in FY 1983. Nearly three-fourths went for purchase of research equipment costing $500 and up, with one-sixth going for maintenance and repair. Purchase of computer-related services showed the widest variation among departments.

Expenditures for research equipment in FY 1983 were analyzed on a per capita and per institution basis. For all departments, the expenditure rate was $5,900 per faculty-level researcher. However, for departments of molecular/cellular biology, expenditures per researcher were $21,800, far greater than those for other types of departments. Apparently, there was a large influx of money into this field in FY 1983.

Medical schools in general had higher expenditures for research equipment than graduate schools within the biological sciences. Expenditures per researcher were 40 percent higher in medical schools, and medical schools spent two and a half times more than graduate schools, per institution, for research equipment in FY 1983.

Private institutions spent nearly twice as much per researcher and 30 percent more per institution than did institutions under public control.

5. THE NATIONAL STOCK OF ACADEMIC RESEARCH EQUIPMENT

A major objective of this survey is to provide baseline estimates for the numbers and costs of instrument systems devoted to research in the nation's universities and medical schools. This chapter also provides estimates for the proportions of instrument systems considered state-of-the-art and obsolete, and unit costs of existing equipment per researcher, doctoral degree granted, and institution.

These estimates are important indicators of the current national stock of academic scientific research equipment. Furthermore, as a baseline against which future changes can be measured, they will be the initial points for determining trends in the status of academic research equipment.

The format of the tables around which discussion will be organized is that appropriate to subfields of research. The data were obtained from the Instrument Data Sheet of the survey, rather than from the Department/Facility Questionnaire used for the two preceding chapters. Each instrument was classified according to the subfield of scientific research in which it was employed, rather than according to the department that carried it on inventory.

5.1 Number and Cost of Instrument Systems

Table 5-1 shows the numbers of instrument systems for graduate schools and medical schools. Between the two settings, there are over 21,000 systems. However, medical schools have more than twice as many systems as graduate schools.

TABLE 5-1
AMOUNT OF ACADEMIC RESEARCH EQUIPMENT, BY SETTING
INSTRUMENT SYSTEMS IN 1983 NATIONAL STOCK: BIOLOGICAL AND MEDICAL SCIENCES

	NUMBER AND PERCENT OF SYSTEMS		
		SETTING	
	TOTAL	GRADUATE SCHOOLS	MEDICAL SCHOOLS
TOTAL	21485 100%	7015 100%	14469 100%
SUBFIELD OF RESEARCH			
BIOCHEMISTRY	4479 21%	1543 22%	2936 20%
MICROBIOLOGY	1640 8%	533 8%	1107 8%
MOLECULAR/CELLULAR BIOLOGY	2943 14%	1460 21%	1483 10%
PHYSIOLOGY/BIOPHYSICS	2720 13%	734 10%	1986 14%
ANATOMY	538 3%	79 1%	459 3%
PATHOLOGY	1014 5%	69 1%	945 7%
PHARMACOLOGY/TOXICOLOGY	2089 10%	186 3%	1903 13%
ZOOLOGY/ENTOMOLOGY	501 2%	328 5%	173 1%
BOTANY	469 2%	447 6%	22 -
FOOD AND NUTRITION	410 2%	393 6%	18 -
BIOLOGY, GENERAL AND N.E.C.	1656 8%	1103 16%	553 4%
MEDICAL SCIENCES/DEPTS MED	2836 13%	57 1%	2779 19%
INTERDISCIPLINARY, N.E.C.	191 1%	84 1%	107 1%
INSTITUTION CONTROL			
PRIVATE	7180 33%	2204 31%	4976 34%
PUBLIC	14305 67%	4812 69%	9493 66%

The number of instrument systems in the various subfields of research ranged widely, with a larger number in biochemistry than in any other subfield -- almost 4,500 (21 percent of all instrument systems). The subfields of botany, zoology, and food/nutrition, found almost exclusively in graduate schools, and anatomy, a medical school subfield, had relatively few systems. Five of the larger subfields -- biochemistry, microbiology, molecular/cellular biology, physiology/biophysics, and general biology -- had significant representation in both settings. Instrument systems used in pathology, pharmacology, and medical sciences were located almost entirely in medical schools.

Turning to the aggregate purchase costs of equipment shown in Table 5-2, the original purchase cost for all $10,000+ equipment in the biological sciences and departments of medicine was about $555 million. The dollar value (aggregate purchase cost) of existing equipment in the fields surveyed was twice as great in medical schools as in non-medical schools. Using the Machinery and Equipment Index of the annual Producer Price Index, these costs were converted into constant 1982 dollars. The total cost was estimated at $863 million. The variation of aggregate costs among the subfields approximates that found for numbers of instruments.

Appendix Table A-4 provides the numbers of instrument systems and their costs for all fields of research. Of all instruments found in both Phase I and Phase II of the study, the biological sciences accounted for 38 percent -- more than any other field. In aggregate costs biology was second by a small amount to the physical sciences, although the latter possessed only 25 percent of the instrument systems. The field with the third largest number of systems was engineering, with 20 percent; all other fields had between 2 and 6 percent of the instrument systems.

TABLE 5-2
AGGREGATE COST OF ACADEMIC RESEARCH EQUIPMENT, BY SETTING
INSTRUMENT SYSTEMS IN 1983 NATIONAL STOCK: BIOLOGICAL AND MEDICAL SCIENCES

(DOLLARS IN MILLIONS)

	COST OF SYSTEMS AND PERCENT OF COST					
			SETTING			
	TOTAL		GRADUATE SCHOOLS		MEDICAL SCHOOLS	
	ORIGINAL PURCHASE COST	COST IN CONSTANT 1982 DOLLARS	ORIGINAL PURCHASE COST	COST IN CONSTANT 1982 DOLLARS	ORIGINAL PURCHASE COST	COST IN CONSTANT 1982 DOLLARS
TOTAL	$555.7 100%	$863.6 100%	$175.3 100%	$272.2 100%	$380.4 100%	$591.4 100%
SUBFIELD OF RESEARCH						
BIOCHEMISTRY	104.3 19%	158.9 18%	36.9 21%	53.9 20%	67.4 18%	105.0 18%
MICROBIOLOGY	40.8 7%	64.1 7%	12.8 7%	20.7 8%	28.0 7%	43.5 7%
MOLECULAR/CELLULAR BIOLOGY	84.5 15%	124.8 14%	38.6 22%	58.5 21%	45.9 12%	66.3 11%
PHYSIOLOGY/BIOPHYSICS	73.9 13%	112.0 13%	18.1 10%	28.8 11%	55.7 15%	83.2 14%
ANATOMY	17.4 3%	31.7 4%	2.1 1%	3.7 1%	15.4 4%	27.9 5%
PATHOLOGY	31.5 6%	53.9 6%	2.1 1%	3.8 1%	29.4 8%	50.2 8%
PHARMACOLOGY/TOXICOLOGY	46.8 8%	69.0 8%	3.8 2%	5.2 2%	43.1 11%	63.8 11%
ZOOLOGY/ENTOMOLOGY	13.1 2%	20.6 2%	7.3 4%	11.9 4%	5.8 2%	8.7 1%
BOTANY	11.4 2%	16.3 2%	10.3 6%	15.2 6%	1.1 -	1.1 -
FOOD AND NUTRITION	8.9 2%	13.3 2%	8.5 5%	12.9 5%	.4 -	.5 -
BIOLOGY, GENERAL AND N.E.C.	47.3 9%	82.2 10%	31.0 18%	52.4 19%	16.3 4%	29.8 5%
MEDICAL SCIENCES/DEPTS MED	69.1 12%	107.2 12%	1.0 1%	1.3 -	68.1 18%	106.0 18%
INTERDISCIPLINARY, N.E.C.	6.8 1%	9.3 1%	2.9 2%	3.8 1%	3.9 1%	5.5 1%
INSTITUTION CONTROL						
PRIVATE	203.8 37%	299.4 35%	58.7 33%	84.0 31%	145.1 38%	215.4 36%
PUBLIC	351.9 63%	564.2 65%	116.6 67%	188.2 69%	235.3 62%	376.0 64%

Overall, about three-fourths of existing research instruments in the survey cost range fell in the $10,000 to $24,999 range, and only five percent cost $75,000 or more (Table 5-3). The cost pattern varied considerably among the subfields, however. More than 75 percent of the instruments in biochemistry, microbiology, pharmacology, botany, and medical sciences were in the lowest cost category. The other subfields ranged downward to a low of 55 percent for anatomy. A difference was also found between the biological sciences (72 percent in the lowest cost group) and departments of medicine (78 percent in that group).

The distribution of aggregate purchase costs among the cost categories (Table 5-4) indicated that the 5 percent of all instruments costing $75,000 or more actually consumed 24 percent of all the money spent on major equipment purchases. Private institutions had 32 percent in the upper cost category, compared to 20 percent for public institutions.

With the exception of agriculture, all other fields of science had a higher proportion of systems costing $75,000 or more than did biology (see Appendix Table A-5). For the physical sciences, 47 percent were in this group, and for engineering 40 percent. Computer science had 57 percent, with materials science and the environmental sciences having almost as much.

5.2 Unit Costs

With varying numbers of instruments and users in the different institutions and subfields of research, it is useful to examine aggregate instrumentation costs in terms of units, such as the number of instrument systems, the number of researchers, and the number of doctoral degrees awarded within a subfield.

TABLE 5-3
DISTRIBUTION OF ACADEMIC RESEARCH EQUIPMENT, BY SYSTEM COST RANGE
INSTRUMENT SYSTEMS IN 1983 NATIONAL STOCK: BIOLOGICAL AND MEDICAL SCIENCES

	--------NUMBER AND PERCENT OF SYSTEMS--------			
		------ORIGINAL PURCHASE COST------		
	TOTAL	$10,000- $24,999	$25,000- $74,999	$75,000- $1,000,000
TOTAL	21470 100%	15638 73%	4826 22%	1006 5%
SUBFIELD OF RESEARCH				
BIOCHEMISTRY	4479 100%	3475 78%	893 20%	110 2%
MICROBIOLOGY	1640 100%	1239 76%	343 21%	58 4%
MOLECULAR/CELLULAR BIOLOGY	2939 100%	1939 66%	861 29%	139 5%
PHYSIOLOGY/BIOPHYSICS	2720 100%	1951 72%	627 23%	142 5%
ANATOMY	535 100%	292 55%	200 37%	43 8%
PATHOLOGY	1014 100%	609 60%	316 31%	90 9%
PHARMACOLOGY/TOXICOLOGY	2089 100%	1639 78%	381 18%	69 3%
ZOOLOGY/ENTOMOLOGY	493 100%	357 73%	107 22%	28 6%
BOTANY	469 100%	369 79%	73 16%	27 6%
FOOD AND NUTRITION	410 100%	293 71%	109 27%	8 2%
BIOLOGY, GENERAL AND N.E.C.	1656 100%	1178 71%	374 23%	104 6%
MEDICAL SCIENCES/DEPTS MED	2836 100%	2173 77%	498 18%	165 6%
INTERDISCIPLINARY, N.E.C.	191 100%	125 65%	43 23%	23 12%
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	17582 100%	12592 72%	4164 24%	826 5%
GRADUATE SCHOOLS	7006 100%	5045 72%	1678 24%	283 4%
MEDICAL SCHOOLS	10577 100%	7547 71%	2486 24%	543 5%
DEPARTMENTS OF MEDICINE	3888 100%	3046 78%	662 17%	180 5%
INSTITUTION CONTROL				
PRIVATE	7167 100%	5092 71%	1640 23%	434 6%
PUBLIC	14303 100%	10546 74%	3185 22%	572 4%

TABLE 5-4
DISTRIBUTION OF AGGREGATE COSTS OF ACADEMIC RESEARCH EQUIPMENT, BY SYSTEM COST RANGE
INSTRUMENT SYSTEMS IN 1983 NATIONAL STOCK: BIOLOGICAL AND MEDICAL SCIENCES

(DOLLARS IN MILLIONS)

	-DOLLARS AND PERCENT OF AGGREGATE PURCHASE COST-			
		---ORIGINAL SYSTEM PURCHASE COST---		
	TOTAL	$10,000- $24,999	$25,000- $74,999	$75,000- $1,000,000
TOTAL	$564.1 100%	$243.0 43%	$184.6 33%	$136.4 24%
SUBFIELD OF RESEARCH				
BIOCHEMISTRY	104.8 100%	55.6 53%	32.4 31%	16.9 16%
MICROBIOLOGY	40.9 100%	19.7 48%	12.8 31%	8.3 21%
MOLECULAR/CELLULAR BIOLOGY	84.8 100%	30.0 35%	33.0 39%	21.7 26%
PHYSIOLOGY/BIOPHYSICS	76.9 100%	30.3 39%	24.0 31%	22.5 29%
ANATOMY	17.7 100%	4.3 24%	9.2 52%	4.2 24%
PATHOLOGY	31.6 100%	9.1 29%	12.7 40%	9.7 31%
PHARMACOLOGY/TOXICOLOGY	48.0 100%	25.6 53%	13.7 29%	8.8 18%
ZOOLOGY/ENTOMOLOGY	13.1 100%	5.4 41%	4.2 32%	3.5 27%
BOTANY	11.4 100%	5.9 51%	2.8 25%	2.8 24%
FOOD AND NUTRITION	9.4 100%	4.6 49%	4.1 44%	.7 7%
BIOLOGY, GENERAL AND N.E.C.	49.1 100%	17.9 36%	15.1 31%	16.1 33%
MEDICAL SCIENCES/DEPTS MED	69.5 100%	32.8 47%	18.7 27%	17.9 26%
INTERDISCIPLINARY, N.E.C.	6.8 100%	1.8 26%	2.0 29%	3.0 43%
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	469.8 100%	196.9 42%	158.5 34%	114.4 24%
GRADUATE SCHOOLS	177.6 100%	77.5 44%	62.0 35%	38.1 21%
MEDICAL SCHOOLS	292.2 100%	119.4 41%	96.4 33%	76.3 26%
DEPARTMENTS OF MEDICINE	94.3 100%	46.1 49%	26.2 28%	22.0 23%
INSTITUTION CONTROL				
PRIVATE	209.5 100%	79.0 38%	63.7 30%	66.9 32%
PUBLIC	354.5 100%	164.0 46%	120.9 34%	69.6 20%

Table 5-5 shows mean purchase costs per institution and per instrument system. Overall, the dollar cost of the current instrumentation inventory in medical schools is nearly four times as large per institution as it is in graduate schools. In this table, medical school totals include the aggregate costs of instrumentation in departments of medicine, so the aggregate cost per institution for only the biological sciences in medical schools would be $3,176,000 -- about three times the mean amount per graduate school. This difference is about the same as that noted earlier in analyses of FY 1983 equipment expenditures (see Table 4-2).

For most subfields (except those located almost entirely outside medical schools -- botany, general biology, etc), the average dollar amount of research equipment per institution was substantially higher in medical schools than in other academic institutions. Public institutions, primarily because they were larger and contained more departments, had slightly larger dollar amounts of research equipment per institution than private schools.

Turning to mean costs per instrument system, there was a notable difference between medical and graduate schools, with medical schools having invested about $1,000 more per instrument system on the average. The difference appeared consistently among the subfields as well. In private institutions the average system cost $29,200, considerably more than the $24,800 cost found in public institutions.

The mean cost of instrument systems in the biological sciences can be compared with mean instrument costs for other fields of science (see Appendix Table A-4). The mean for biological sciences ($27,000) was the lowest for any field except agriculture. Computer science had the highest mean cost, $54,000. Costs for environmental sciences averaged $47,000, and the mean was $41,000 for the physical sciences.

TABLE 5-9
MEAN AGGREGATE ORIGINAL PURCHASE COST OF ACADEMIC RESEARCH EQUIPMENT PER INSTITUTION AND PER INSTRUMENT SYSTEM, BY SETTING
INSTRUMENT SYSTEMS IN 1983 NATIONAL STOCK: BIOLOGICAL AND MEDICAL SCIENCES

[MEAN COST DOLLARS IN THOUSANDS]

	COST PER INSTITUTION		COST PER INSTRUMENT SYSTEM	
	GRADUATE SCHOOLS	MEDICAL SCHOOLS	GRADUATE SCHOOLS	MEDICAL SCHOOLS
TOTAL	$1,116.6	$4,135.0	$25.0	$26.3
SUBFIELD OF RESEARCH				
BIOCHEMISTRY	235.9	732.2	23.9	23.0
MICROBIOLOGY	81.7	303.9	24.0	25.3
MOLECULAR/CELLULAR BIOLOGY	246.0	498.9	26.4	31.0
PHYSIOLOGY/BIOPHYSICS	115.4	605.8	24.7	28.0
ANATOMY	13.1	166.9	26.6	33.6
PATHOLOGY	13.1	319.8	30.4	31.1
PHARMACOLOGY/TOXICOLOGY	24.0	468.1	20.4	22.6
ZOOLOGY/ENTOMOLOGY	46.4	63.4	22.3	33.5
BOTANY	65.7	11.9	23.0	*
FOOD AND NUTRITION	53.9	4.3	21.6	*
BIOLOGY, GENERAL AND N.E.C.	197.3	177.1	28.1	29.5
MEDICAL SCIENCES/DEPTS MED	6.3	740.6	17.5	24.5
INTERDISCIPLINARY, N.E.C.	18.4	42.2	34.5	36.4
INSTITUTION CONTROL				
PRIVATE	1,107.4	3,628.6	26.6	29.2
PUBLIC	1,121.4	4,524.6	24.2	24.8

* NUMBER OF CASES IN THE UNDERLYING SAMPLE WAS INSUFFICIENT FOR A RELIABLE ESTIMATE.

Since the amount of research activity in the several biological science subfields varies considerably, numerical comparisons among the subfields are dominated by the relative "size" of the enterprise. In an attempt to normalize between-subfield comparisons, instrument numbers and costs were calculated per researcher and per doctoral student. The resulting ratios are only indices and do not represent actual one-time costs per researcher or per degree awarded.

In Table 5-6, mean aggregate costs of existing instrument systems per researcher and per doctoral degree awarded are shown by field and setting and by institution control. The numbers of researchers and doctoral degrees are also shown in Table 5-6. The overall mean aggregate cost of equipment per researcher was $21,000. There was a sizable difference in the biological sciences, however, between medical schools (where the mean is $27,600 per researcher), and graduate schools (with a mean of $18,400 per researcher). For private institutions the cost per researcher was $25,000, while for public institutions it was $19,400.

These aggregate equipment costs per researcher may be compared with the analogous FY 1983 expenditures shown in Table 4-2. The ratio of aggregate equipment cost per researcher for medical schools to graduate schools is 1.5; for 1983 equipment expenditures, the ratio is 1.41. The corresponding ratios for private institutions to public institutions are 1.29 for aggregate equipment costs and 1.69 for 1983 equipment expenditures. Another comparison is the ratio of the biological sciences in medical schools to departments of medicine. For aggregate equipment costs that ratio is 1.86; it is 1.85 for 1983 equipment expenditures.

TABLE 5-6
MEAN AGGREGATE PURCHASE COST OF ACADEMIC RESEARCH EQUIPMENT PER DOCTORAL DEGREE AWARDED AND PER FACULTY-LEVEL RESEARCHER
INSTRUMENT SYSTEMS IN 1983 NATIONAL STOCK: BIOLOGICAL AND MEDICAL SCIENCES

[MEAN COST DOLLARS IN THOUSANDS]

	DOCTORAL DEGREES [1]		FACULTY-LEVEL RESEARCHERS [2]	
	NUMBER	COST PER DEGREE	NUMBER	COST PER RESEARCHER
TOTAL	3,275	$172.2	26,635	$21.2
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	3,275	143.5	20,248	23.2
GRADUATE SCHOOLS	1,946	91.3	9,654	18.4
MEDICAL SCHOOLS	1,329	219.9	10,594	27.6
DEPARTMENTS OF MEDICINE	-	-	6,386	14.8
INSTITUTION CONTROL				
PRIVATE	919	228.0	8,366	25.0
PUBLIC	2,362	150.1	18,268	19.4

[1] RESEARCH DOCTORATES AWARDED DURING 1982-83 BY DEPARTMENTS IN THE GRADUATE AND MEDICAL SCHOOLS OF THE SURVEY UNIVERSE, AS REPORTED BY DEPARTMENT HEADS.

[2] NUMBER OF FACULTY AND EQUIVALENT NON-FACULTY RESEARCHERS (FULL-TIME AND PART-TIME) WHO PARTICIPATE IN ONGOING RESEARCH PROJECTS AND WHO ARE MEMBERS OF THE DEPARTMENTS OF THE GRADUATE AND MEDICAL SCHOOLS IN THE SURVEY UNIVERSE, AS REPORTED BY DEPARTMENT HEADS.

Of course, the expenditures for 1983 are reflected in the aggregate equipment costs. The 1983 numbers, however, are the latest available single year estimates of level of investment in research instrumentation for the institutions and fields represented in this survey, while aggregate costs are an accumulation of more than 15 years of equipment investments. There is a notable consistency in the patterns these two sets of statistics follow, suggesting that current expenditure levels are generally consistent with long-range historical trends. However, for the comparison of private and public institutions, the ratios show a wider gap for 1983 equipment expenditures than for the long term aggregate costs. While this is an observation for only one year, this finding suggests that the long-standing gap in equipment expenditures between private and public institutions may be increasing.

The average dollar amount of instrumentation per doctoral degree awarded in the biological sciences was $143,500. Biological science departments in medical schools had a far higher mean per degree than did graduate schools, $219,860 to $91,300. Since departments of medicine do not award doctoral degrees, this statistic is not applicable to them. Private institutions' mean amount of equipment per degree was $228,000, compared to $150,000 for public institutions.

The dollar amount of research equipment per doctoral degree can be estimated for each subfield, but it is necessary to consult another source for the denominator data. The National Research Council conducts an annual survey of doctorate recipients and reports not only by broad discipline, but also by fine field within disciplines.[11] By grouping the data for the fine fields to correspond to the subfield categories used in this study, it was possible to compute the mean dollar amount of research equipment per doctoral degree, by subfield. To smooth out the effects of annual fluctuations, especially for subfields with small numbers of degrees, the mean annual number of doctorates awarded, averaged over the four-year period, 1980 to 1983, was used as the denominator in the calculations.

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[11] Summary Report 1983, Doctorate Recipients from United States Universities, Office of Scientific and Engineering Personnel, National Research Council, National Academy Press, 1983, p.47.

Table 5-7 shows that the annual number of doctoral degrees, 3,864, is larger than the 3,281 found earlier from the data reported by department heads. The difference results primarily from the larger base of institutions from which the National Research Council (NRC) collected its data. While the base of institutions for this study was the 249 universities and medical schools that collectively spend 95 percent of the nation's R&D funds, NRC used all doctorate-granting institutions. The aggregate costs of instrument systems per doctoral degree awarded for biological sciences as a whole becomes $121,600 by this measure.

The subfields of research varied widely in instrument costs per degree awarded. The four subfields that are almost entirely located in graduate schools -- zoology, botany, food/nutrition, and general biology -- were far lower in mean dollar amount of research equipment per degree than the other subfields. At the upper end was pathology (largely a medical school field) with a mean of $310,000 of equipment per degree. Molecular/cellular biology, physiology/biophysics, biochemistry, and pharmacology also had means of over $160,000 in research equipment per degree. The remaining fields had substantially lower amounts of equipment per degree than those mentioned.

TABLE 5-7
AVERAGE NUMBER OF DOCTORATES AWARDED ANNUALLY FROM 1980 TO 1983 AND
AGGREGATE INSTRUMENT COSTS PER DEGREE
INSTRUMENT SYSTEMS IN 1983 NATIONAL STOCK: BIOLOGICAL AND MEDICAL SCIENCES

(DOLLARS IN THOUSANDS)

	NUMBER OF DOCTORAL DEGREES (1)	INSTRUMENT COST PER DEGREE (2)
BIOLOGICAL SCIENCES, TOTAL	3,864	$121.6
SUBFIELS OF RESEARCH		
BIOCHEMISTRY	653	160.3
MICROBIOLOGY	485	84.3
MOLECULAR/CELLULAR BIOLOGY	434	195.4
PHYSIOLOGY/BIOPHYSICS	401	191.8
ANATOMY	148	184.6
PATHOLOGY	102	309.8
PHARMACOLOGY/TOXICOLOGY	272	176.5
ZOOLOGY/ENTOMOLOGY	426	30.0
BOTANY	206	55.3
FOOD AND NUTRITION	219	42.9
BIOLOGY, GENERAL AND N.E.C.	514	95.5

(1) SOURCE OF DATA: SUMMARY REPORT 1983, DOCTORATE RECIPIENTS FROM UNITED STATES UNIVERSITIES. OFFICE OF SCIENTIFIC AND ENGINEERING PERSONNEL, NATIONAL RESEARCH COUNCIL, NATIONAL ACADEMY PRESS, 1983, p.47.

(2) AGGREGATE ORIGINAL PURCHASE COST.

5.3 State-of-the-Art and Obsolete Instrument Systems

State-of-the-art instruments constituted 18 percent of all biological and medical science instruments in the 1983 national stock of academic research equipment (see Table 5-8). Other instruments in research use in 1983 accounted for an additional 65 percent of the national stock, so that a total of 83 percent of all instrument systems in the national stock were in active research use in 1983.

The remainder of the national stock consisted of a negligible number (less than one percent) of systems waiting to be put into service and 16 percent that were no longer in use although they were still physically present at their respective institutions. The instruments in the latter group were, presumably, technologically obsolete and/or mechanically inoperable.

As compared to public institutions, private institutions have proportionately more state-of-the-art research equipment (23% of the private school national stock vs. 16% of the public school national stock). For the most part, however, there are remarkably few differences between institutions or subfields in the research status of the current stock of research equipment.

Table 5-9 reveals that the 18 percent of instruments classified as state-of-the-art were responsible for 25 percent of the aggregate cost of all equipment in the national stock; these instruments had a mean cost of $36,200 per system. Other instruments in research use averaged $24,700 per system, and those no longer in research use averaged $21,100. Means were calculated by dividing aggregate costs in Table 5-9 by numbers

TABLE 5-9
RESEARCH STATUS OF ACADEMIC RESEARCH EQUIPMENT
INSTRUMENT SYSTEMS IN 1983 NATIONAL STOCK: BIOLOGICAL AND MEDICAL SCIENCES

	NUMBER AND PERCENT OF SYSTEMS				
		SYSTEM RESEARCH STATUS			
		IN RESEARCH USE		NOT YET IN RESEARCH USE	NO LONGER IN RESEARCH USE
	TOTAL	STATE-OF-THE-ART	OTHER		
TOTAL	21485 100%	3881 18%	14021 65%	142 1%	3440 16%
SUBFIELD OF RESEARCH					
BIOCHEMISTRY	4479 100%	801 18%	3304 74%	2 -	373 8%
MICROBIOLOGY	1640 100%	242 15%	1209 74%	2 -	186 11%
MOLECULAR/CELLULAR BIOLOGY	2943 100%	832 28%	2010 68%	0	101 3%
PHYSIOLOGY/BIOPHYSICS	2720 100%	519 19%	1822 67%	41 2%	338 12%
ANATOMY	538 100%	135 25%	316 59%	0	87 16%
PATHOLOGY	1014 100%	173 17%	601 59%	17 2%	223 22%
PHARMACOLOGY/TOXICOLOGY	2089 100%	237 11%	1524 73%	32 2%	296 14%
ZOOLOGY/ENTOMOLOGY	501 100%	124 25%	298 59%	2 -	77 15%
BOTANY	469 100%	106 23%	330 70%	0	33 7%
FOOD AND NUTRITION	410 100%	88 22%	259 63%	8 2%	55 13%
BIOLOGY, GENERAL AND N.E.C.	1636 100%	177 11%	821 50%	21 1%	628 38%
MEDICAL SCIENCES/DEPTS MED	2836 100%	369 13%	1415 50%	18 1%	1034 36%
INTERDISCIPLINARY, N.E.C.	191 100%	77 40%	114 60%	0	0
FIELD AND SETTING					
BIOLOGICAL SCIENCES, TOTAL	17597 100%	3251 18%	11816 67%	124 1%	2406 14%
GRADUATE SCHOOLS	7015 100%	1372 19%	4737 68%	32 -	874 12%
MEDICAL SCHOOLS	10582 100%	1899 18%	7059 67%	92 1%	1532 14%
DEPARTMENTS OF MEDICINE	3887 100%	631 16%	2204 57%	18 -	1034 27%
INSTITUTION CONTROL					
PRIVATE	7180 100%	1641 23%	4522 63%	44 1%	973 14%
PUBLIC	14305 100%	2241 16%	9500 66%	98 1%	2466 17%

TABLE 5-9
AGGREGATE COST OF ACADEMIC RESEARCH EQUIPMENT, BY SYSTEM RESEARCH STATUS
INSTRUMENT SYSTEMS IN 1983 NATIONAL STOCK: BIOLOGICAL AND MEDICAL SCIENCES

(DOLLARS IN MILLIONS)

	AGGREGATE PURCHASE COST AND PERCENT OF COST				
		SYSTEM RESEARCH STATUS			
		IN RESEARCH USE		NOT YET IN RESEARCH USE	NO LONGER IN RESEARCH USE
	TOTAL	STATE-OF-THE-ART	OTHER		
TOTAL	$564.0 100%	$140.3 25%	$346.3 61%	$4.5 1%	$72.6 13%
SUBFIELD OF RESEARCH					
BIOCHEMISTRY	104.8 100%	25.7 25%	72.2 69%	.5 1%	6.4 6%
MICROBIOLOGY	40.9 100%	9.1 22%	28.1 69%	.2 -	3.6 9%
MOLECULAR/CELLULAR BIOLOGY	84.8 100%	34.5 41%	48.2 57%	0	2.1 3%
PHYSIOLOGY/BIOPHYSICS	76.9 100%	20.2 26%	49.4 64%	.9 1%	6.3 8%
ANATOMY	17.8 100%	4.4 25%	10.7 60%	0	2.6 15%
PATHOLOGY	31.6 100%	6.0 19%	19.3 61%	.5 2%	5.8 18%
PHARMACOLOGY/TOXICOLOGY	48.8 100%	9.1 19%	31.0 63%	.9 2%	7.8 16%
ZOOLOGY/ENTOMOLOGY	13.1 100%	3.8 29%	7.7 59%	.1 -	1.6 12%
BOTANY	11.4 100%	3.6 32%	7.2 63%	0	.6 5%
FOOD AND NUTRITION	9.4 100%	2.4 25%	5.4 58%	.5 5%	1.1 12%
BIOLOGY, GENERAL AND N.E.C.	49.1 100%	8.7 18%	25.1 51%	.6 1%	14.8 30%
MEDICAL SCIENCES/DEPTS MED	69.5 100%	11.2 16%	37.4 54%	.3 -	20.5 30%
INTERDISCIPLINARY, N.E.C.	6.8 100%	2.0 30%	4.8 71%	0	0
FIELD AND SETTING					
BIOLOGICAL SCIENCES, TOTAL	469.8 100%	121.8 26%	291.7 62%	4.2 1%	52.1 11%
GRADUATE SCHOOLS	177.6 100%	46.2 26%	110.8 62%	1.7 1%	18.9 11%
MEDICAL SCHOOLS	292.2 100%	75.7 26%	180.9 62%	2.5 1%	33.2 11%
DEPARTMENTS OF MEDICINE	94.3 100%	18.7 20%	54.8 58%	.3 -	20.5 22%
INSTITUTION CONTROL					
PRIVATE	209.6 100%	65.3 31%	120.0 57%	1.8 1%	22.5 11%
PUBLIC	354.5 100%	75.3 21%	226.5 64%	2.7 1%	50.1 14%

of systems from Table 5-8. These average costs must be interpreted with some caution, however, for state-of-the-art instruments were acquired almost entirely within the last five years, as will be shown in the following chapter on Age and Condition of Equipment. Other instruments still in research use had a much broader spread of acquisition dates, while the majority of those no longer in research use were over 10 years old. Inflation was a significant factor over this period of time, and expenditures for instruments in each of these research status categories were affected differently by inflation.

Among subfields, there were substantial differences in mean costs of state-of-the-art systems. General biology's state-of-the-art instruments cost an average of $49,200, and those for molecular/cellular biology cost an average of $41,500. Those with the least expensive state-of-the-art instruments were food/nutrition ($27,300) and medical sciences ($30,300). The mean cost of state-of-the-art instruments in biochemistry, the subfield with the largest number of items, was $32,100.

Private institutions again showed a bias toward more expensive equipment, with a state-of-the-art average of $39,800, as compared to a $33,600 average for public institutions.

5.4 Summary

There were over 21,000 instrument systems, with an estimated aggregate original purchase cost of $555 million, in the biological sciences and departments of medicine encompassed by this survey. The cost of these instrument systems in constant 1982 dollars was estimated to be $863 million. The largest single subfield of the biological sciences, with nearly 4,500 instruments in the $10,000 to $1 million cost range, was biochemistry.

The biological sciences had more instrument systems than any other field of science surveyed, 38 percent. The physical sciences had 25 percent of all systems, but their aggregate cost was slightly greater than that for the biological sciences. The mean cost per instrument system for biological sciences was $27,000, the lowest for any field of science except agriculture. By comparison, the average cost per instrument for physical sciences was $41,000.

About five percent of all instruments included in the study had an original purchase cost between $75,000 and $1 million; however, these accounted for about one-fourth of the aggregate cost of all extant research instrument systems costing over $10,000. Almost three-fourths of the systems cost between $10,000 and $24,999.

Medical schools spent three times as much per institution for instrumentation in biological sciences as graduate schools. The mean dollar amount of equipment per researcher for the biological sciences, about $21,000 overall, was about 50 percent higher for medical schools than for graduate schools. For departments of medicine the cost per researcher was lower, about $15,000. This, apparently, was reflective of the exceptionally large numbers of faculty-level researchers associated with departments of medicine. Private institutions had higher instrument investments per researcher than public institutions. The levels of the differences found for aggregate cost of equipment per researcher and per institution closely paralleled those found in Chapter 4 for FY 1983 equipment expenditures. Apparently, there is a consistency over time in relative expenditures for these groups.

During 1982-83 the mean dollar amount of research instrumentation per doctoral degree awarded in the biological sciences was $143,500. However, for medical schools the mean was $220,000, compared to $91,000 for graduate schools. Private institutions also had somewhat higher costs per doctoral degree awarded than public institutions.

State-of-the-art instruments constituted 18 percent of the national stock, while instruments that were not state-of-the-art but *were* in active research use accounted for another 65 percent of the national stock. Another 16 percent were no longer in active use, apparently because of technological obsolescence or mechanical disrepair.

State-of-the-art instruments cost, on the average, over $36,000 per instrument, but other instruments that were in active use (and were usually purchased earlier) cost a little less than $25,000 per instrument. There was also a difference in mean cost for state-of-the-art instruments in favor of private institutions over public institutions, about $40,000 to about $34,000.

6. AGE AND CONDITION OF RESEARCH EQUIPMENT

The age and operating condition of research instrumentation available to the nation's academic researchers has been the subject of many anecdotal reports, and it has been a major subject of inquiry in the present survey.

It was disclosed in the preceding chapter (Table 5-8) that, for the biological sciences and departments of medicine as a whole, 16 percent of the 1983 national stock of academic research instrumentation was not used at all during the year, apparently because of mechanical or technological obsolescence. A few new instruments were still being prepared for use in the laboratory. The remainder were actively used for research in 1983. In this chapter, statistics will first be presented on the age of all equipment in the national stock. Then, the emphasis will shift to instrument systems in active research use in 1983, the 83 percent of the national stock still in use.

6.1 Age of Research Equipment

For the biological sciences and departments of medicine as a whole, 44 percent of the systems in the 1983 national stock were 5 years old or less, and 29 percent were between 6 and 10 years old. The remaining 27 percent were over 10 years old (Table 6-1). There was variation among subfields of research: three of the subfields that are predominately in graduate schools (zoology, botany, and food/nutrition) had more than half of their instrument systems in the one-to-five year age range. At the other extreme, anatomy and general biology had the highest proportions of systems over 10 years old, with 41 percent for anatomy and 37 percent for general biology.

TABLE 6-1
AGE OF ACADEMIC RESEARCH EQUIPMENT
INSTRUMENT SYSTEMS IN 1983 NATIONAL STOCK: BIOLOGICAL AND MEDICAL SCIENCES

	NUMBER AND PERCENT OF SYSTEMS			
		SYSTEM AGE (FROM YEAR OF PURCHASE)		
	TOTAL	1-5 YEARS (1979-83)	6-10 YEARS (1974-78)	OVER 10 YEARS (1973 OR BEFORE)
TOTAL	21373 100%	9428 44%	6239 29%	5706 27%
SUBFIELD OF RESEARCH				
BIOCHEMISTRY	4463 100%	2024 45%	1278 29%	1161 26%
MICROBIOLOGY	1633 100%	630 39%	566 35%	438 27%
MOLECULAR/CELLULAR BIOLOGY	2933 100%	1416 48%	855 29%	663 23%
PHYSIOLOGY/BIOPHYSICS	2702 100%	1320 49%	716 26%	667 25%
ANATOMY	530 100%	211 39%	100 19%	219 41%
PATHOLOGY	1014 100%	390 38%	296 29%	328 32%
PHARMACOLOGY/TOXICOLOGY	2086 100%	929 44%	599 29%	558 27%
ZOOLOGY/ENTOMOLOGY	501 100%	180 36%	98 20%	122 24%
BOTANY	469 100%	247 53%	112 24%	110 23%
FOOD AND NUTRITION	400 100%	207 52%	101 25%	92 23%
BIOLOGY, GENERAL AND N.E.C.	1631 100%	487 30%	544 33%	600 37%
MEDICAL SCIENCES/DEPTS MED	2812 100%	1170 42%	911 32%	731 26%
INTERDISCIPLINARY, N.E.C.	191 100%	118 62%	56 30%	17 9%
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	17509 100%	7670 44%	5027 29%	4811 27%
GRADUATE SCHOOLS	6966 100%	3240 47%	1821 26%	1906 27%
MEDICAL SCHOOLS	10543 100%	4431 42%	3207 30%	2906 28%
DEPARTMENTS OF MEDICINE	3846 100%	1738 45%	1213 31%	895 23%
INSTITUTION CONTROL				
PRIVATE	7142 100%	3405 48%	2118 30%	1619 23%
PUBLIC	14231 100%	6023 42%	4121 29%	4087 29%

Private institutions had 6 percent more instruments that were 1 to 5 years old than did public institutions, with 6 percent fewer in the over-10-year category.

The biological sciences had somewhat older instrument systems than did most other fields of science (Appendix Table A-7). Several fields -- agricultural sciences, environmental sciences, engineering, and particularly computer science -- had larger proportions of instruments that were from 1 to 5 years old than did the biological sciences.

State-of-the-art systems constituted 18 percent of all biological and medical science instruments in the national stock (Table 6-2). The percentages of systems acquired each year that were still considered to be state-of-the-art in 1983 are charted in Figure 6-1. For example, 50 percent of the systems acquired in 1983 were state-of-the-art, while 41 percent of those purchased the year before were still state-of-the-art. This diminished to 37 percent of those purchased in 1981; it was down to 8 percent of those acquired during 1974 to 1978 and was practically zero for the earlier years. One conclusion is that five years is essentially the outer limit for equipment to remain state-of-the-art, with the falling off starting after the first year.

At private institutions, 23 percent of the instruments were classified as state-of-the-art, while 16 percent of those in public institutions were so classified. The decline with instrument age is roughly parallel for the two groups of institutions.

The remaining tables in this chapter describe systems in active research use in 1983, a subset of all instruments in the national stock. Table 6-3 shows the age distribution of actively used equipment. Fifty percent were five years old or

TABLE 6-8
PERCENT OF ACADEMIC RESEARCH EQUIPMENT THAT IS STATE-OF-THE-ART BY YEAR OF PURCHASE
INSTRUMENT SYSTEMS IN 1983 NATIONAL STOCK : BIOLOGICAL AND MEDICAL SCIENCES

	---PERCENT OF SYSTEMS CLASSIFIED AS STATE-OF-THE-ART---							
		----------YEAR OF PURCHASE----------						
	TOTAL	1983	1982	1981	1980	1979	1974-1978	BEFORE 1974
TOTAL	18%	50%	41%	37%	23%	22%	8%	2%
FIELD AND SETTING								
BIOLOGICAL SCIENCES, TOTAL	18%	49%	41%	38%	25%	19%	9%	2%
GRADUATE SCHOOLS	17%	53%	44%	38%	26%	16%	12%	1%
MEDICAL SCHOOLS	18%	48%	38%	44%	24%	22%	7%	3%
DEPARTMENTS OF MEDICINE	16%	54%	40%	32%	15%	33%	4%	1%
INSTITUTION CONTROL								
PRIVATE	23%	53%	48%	44%	29%	30%	10%	2%
PUBLIC	16%	48%	40%	33%	22%	18%	6%	2%

Figure 6-1. Percent of Equipment in the National Stock That Is State-of-the-Art in 1983, by Year of Purchase.

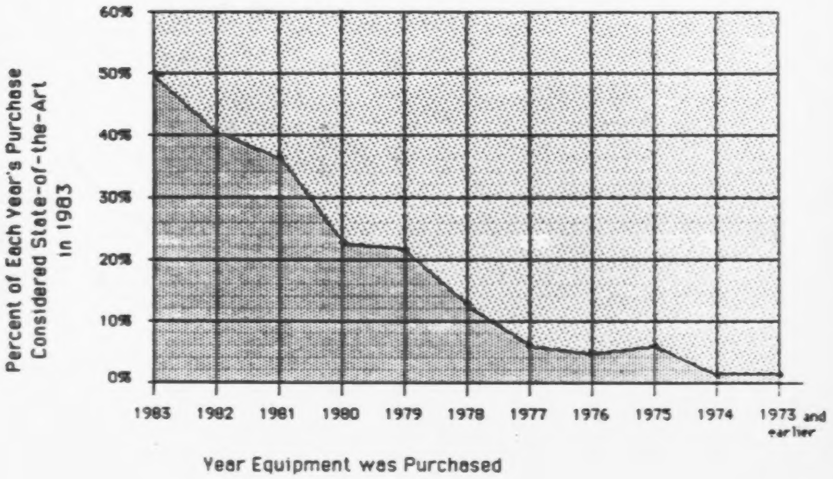


TABLE 6-8
AGE OF ACADEMIC RESEARCH EQUIPMENT
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

		NUMBER AND PERCENT OF IN-USE SYSTEMS		
		SYSTEM AGE (FROM YEAR OF PURCHASE)		
	TOTAL	1-5 YEARS (1979-83)	6-10 YEARS (1974-78)	OVER 10 YEARS (1973 OR BEFORE)
TOTAL	17855 100%	8896 50%	5117 29%	3843 22%
SUBFIELD OF RESEARCH				
BIOCHEMISTRY	4097 100%	2006 49%	1110 27%	981 24%
MICROBIOLOGY	1452 100%	613 42%	526 36%	312 21%
MOLECULAR/CELLULAR BIOLOGY	2832 100%	1406 50%	824 29%	602 21%
PHYSIOLOGY/BIOPHYSICS	2331 100%	1261 54%	612 26%	457 20%
ANATOMY	450 100%	200 44%	95 21%	155 34%
PATHOLOGY	775 100%	334 43%	238 31%	203 26%
PHARMACOLOGY/TOXICOLOGY	1756 100%	858 49%	518 29%	381 22%
ZOOLOGY/ENTOMOLOGY	422 100%	268 63%	86 20%	68 16%
BOTANY	436 100%	245 56%	103 24%	89 20%
FOOD AND NUTRITION	343 100%	198 58%	85 25%	60 18%
BIOLOGY, GENERAL AND N.E.C.	986 100%	402 41%	352 36%	233 24%
MEDICAL SCIENCES/DEPTS MED	1784 100%	989 55%	511 29%	284 16%
INTERDISCIPLINARY, N.E.C.	191 100%	118 62%	56 30%	17 9%
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	15019 100%	7319 49%	4305 29%	3395 23%
GRADUATE SCHOOLS	6088 100%	3132 51%	1568 26%	1387 23%
MEDICAL SCHOOLS	8931 100%	4187 47%	2737 31%	2008 22%
DEPARTMENTS OF MEDICINE	2836 100%	1577 56%	811 29%	447 16%
INSTITUTION CONTROL				
PRIVATE	6136 100%	3284 54%	1787 29%	1065 17%
PUBLIC	11719 100%	5612 48%	3329 28%	2778 24%

less, 29 percent were from 6 to 10 years old, and 22 percent were over 10 years old. The major difference between these and the national stock statistics shown in Table 6-1 was in the number of instrument systems that were over 10 years old. This difference of 1,863 systems in the over-10-years old category was 54 percent of the total number of systems that were no longer in research use (Table 5-8). Thus, as would be expected, obsolete and inoperable equipment tended to be older.

All the subfields had substantial numbers of instruments removed from the over-10-years old category in the change from national stock to instruments actively in research use. The subfields with the largest proportions of instruments removed were general biology and medical sciences. Even after removal of instruments not in use, 35 percent of the in-use instruments in anatomy were over 10 years old, more than any other subfield. Apparently, older instruments are more useful in research for this discipline than for the other subfields.

Departments of medicine displayed a different pattern than the biological sciences in age of instruments in research use. They had 56 percent of their instruments in the 1-to-5 year range, compared to 49 percent for the biological sciences, and they had 16 percent over 10 years old, whereas the biological sciences had 23 percent in this category.

The contrast between departments of medicine and the biological sciences extends to their difference in prevalence of instruments no longer in research use. Departments of medicine contained twice the proportion of such instruments as biological sciences in the national stock (Table 5-8). When these were removed from the count to determine the proportions of instruments actually in research use, it was discovered that only 44 percent of the instruments that were no longer in use in departments of medicine in 1983 were over 10 years old, whereas for the biological sciences 60 percent of those no longer in use were over 10 years old. This difference indicates a tendency to discard instruments at an earlier age in departments of medicine than in the biological sciences. It also suggests that fields, institutions, or departments that have large amounts of unused, retired instrumentation lying about are not necessarily ill-equipped. In some circumstances, this may actually indicate a comparatively well-funded instrumentation situation.

There was a difference between private and public institutions in age distribution. For private institutions, 54 percent of in-use systems were from 1 to 5 years old, and 17 percent were over 10 years old. For public institutions the comparable figures were 48 percent for instruments 1 to 5 years old and 24 percent for those over 10 years old.

Compared with other fields of science (Appendix Table A-8), the tendency of the biological sciences to have older instrument systems becomes even more pronounced when only those systems still in active use are examined. In the instrument age range of 1 to 5 years, the differences between biology and the other fields were somewhat larger for instruments in active use than they were for the full national stock.

State-of-the-art systems constituted 22 percent of all those that were in use during 1983. This percentage was calculated from the data in Table 5-8, after eliminating the inactive equipment. The age distribution of state-of-the-art instruments in active use is shown in Table 6-4. For all subfields combined, 85 percent were between 1 and 5 years old. Anatomy and general biology, however, had only about 65 percent of their state-of-the-art instruments in the 1 to 5 year group. For departments of medicine, 91 percent of the state-of-the-art instruments were

TABLE 6-9
AGE OF ACADEMIC RESEARCH EQUIPMENT
STATE-OF-THE-ART INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

	NUMBER AND PERCENT OF STATE-OF-THE-ART SYSTEMS	SYSTEM AGE (FROM YEAR OF PURCHASE)		
	TOTAL	1-5 YEARS (1979-83)	6-10 YEARS (1974-78)	OVER 10 YEARS (1973 OR BEFORE)
TOTAL	3864 100%	3269 85%	482 12%	114 3%
SUBFIELD OF RESEARCH				
BIOCHEMISTRY	796 100%	709 89%	67 8%	20 3%
MICROBIOLOGY	242 100%	212 87%	31 13%	0
MOLECULAR/CELLULAR BIOLOGY	832 100%	657 79%	150 18%	25 3%
PHYSIOLOGY/BIOPHYSICS	516 100%	445 86%	65 13%	6 1%
ANATOMY	135 100%	91 68%	36 27%	8 6%
PATHOLOGY	173 100%	132 76%	24 14%	17 10%
PHARMACOLOGY/TOXICOLOGY	233 100%	201 86%	19 8%	13 5%
ZOOLOGY/ENTOMOLOGY	124 100%	117 94%	1 1%	6 5%
BOTANY	106 100%	93 88%	10 9%	3 3%
FOOD AND NUTRITION	88 100%	80 90%	8 10%	0
BIOLOGY, GENERAL AND N.E.C.	171 100%	109 64%	51 30%	11 7%
MEDICAL SCIENCES/DEPTS MED	349 100%	336 97%	10 3%	3 1%
INTERDISCIPLINARY, N.E.C.	77 100%	66 86%	9 12%	2 3%
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	3234 100%	2696 83%	434 13%	103 3%
GRADUATE SCHOOLS	1348 100%	1106 82%	215 16%	27 2%
MEDICAL SCHOOLS	1886 100%	1591 84%	219 12%	77 4%
DEPARTMENTS OF MEDICINE	631 100%	572 91%	48 8%	11 2%
INSTITUTION CONTROL				
PRIVATE	1628 100%	1376 85%	214 13%	38 2%
PUBLIC	2236 100%	1892 85%	268 12%	76 3%

five years old or less, compared with 83 percent for the biological sciences. Overall, only 3 percent of state-of-the-art instruments were ten or more years old.

The remaining instrument systems in research use were not state-of-the-art. This group had a very different age pattern than that for the state-of-the-art systems. Figure 6-2 illustrates the contrast. Whereas 85 percent of the state-of-the-art systems were from 1 to 5 years old, the others were more widely distributed over the age categories: 40 percent were from 1 to 5 years old, 33 percent between 6 and 10 years old, 19 percent from 11 to 15 years old, and 8 percent over 15 years.

6.2 Condition of Research Equipment

Aside from the age of the equipment, an important issue addressed by this study is how well academic research equipment is actually performing. The next two tables provide some insight into this question. Table 6-5 details how many of the instruments in active research use were in excellent working condition, and Table 6-6 reveals what function they served in the laboratory.

About half of all instrument systems in the study were considered by the responsible research investigator to be in excellent working condition (Table 6-5). Since a relationship has already been found between the age of instruments and their removal from active research use (Table 6-3 and ensuing discussion), it can reasonably be assumed that there is a relationship between the working condition of instruments and their age. This relationship is shown in Figure 6-3, which gives the percentage of instruments in excellent condition by year of purchase, grouped into three-year periods. For instruments purchased between 1981 and 1983, 78 percent were in excellent condition.

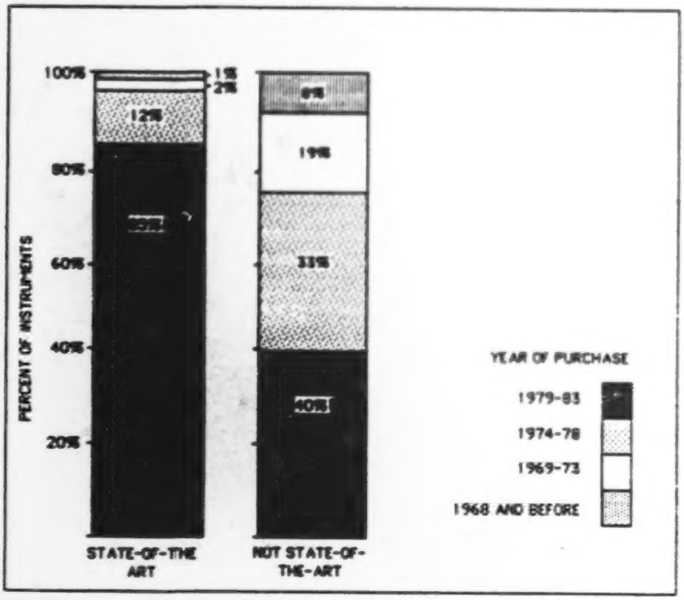


Figure 6-2. Age Distribution of Academic Research Equipment in Active Research Use: Biological and Medical Sciences.

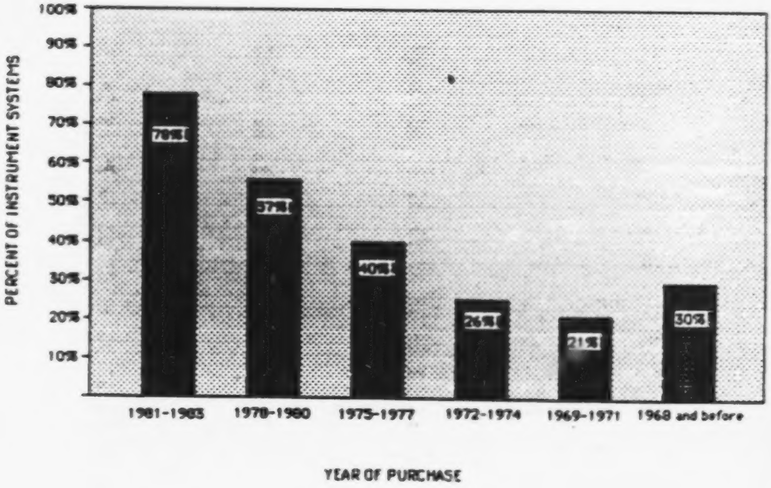
TABLE 6-8
PERCENT OF ACADEMIC RESEARCH EQUIPMENT IN EXCELLENT WORKING CONDITION,
BY RESEARCH STATUS
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

	PERCENT OF SYSTEMS IN EXCELLENT WORKING CONDITION		
		-----1983 RESEARCH STATUS-----	
	TOTAL	STATE-OF-THE-ART SYSTEMS	OTHER IN-USE SYSTEMS
TOTAL	53%	85%	44%
SUBFIELD OF RESEARCH			
BIOCHEMISTRY	47%	79%	40%
MICROBIOLOGY	49%	81%	42%
MOLECULAR/CELLULAR BIOLOGY	59%	90%	46%
PHYSIOLOGY/BIOPHYSICS	60%	89%	52%
ANATOMY	58%	81%	48%
PATHOLOGY	50%	88%	39%
PHARMACOLOGY/TOXICOLOGY	46%	81%	40%
ZOOLOGY/ENTOMOLOGY	64%	94%	51%
BOTANY	53%	78%	50%
FOOD AND NUTRITION	60%	86%	51%
BIOLOGY, GENERAL AND N.E.C.	59%	89%	52%
MEDICAL SCIENCES/DEPTS MED	49%	81%	41%
INTERDISCIPLINARY, N.E.C.	55%	73%	42%
FIELD AND SETTING			
BIOLOGICAL SCIENCES, TOTAL	53%	85%	44%
GRADUATE SCHOOLS	54%	88%	44%
MEDICAL SCHOOLS	52%	82%	43%
DEPARTMENTS OF MEDICINE	55%	83%	47%
INSTITUTION CONTROL			
PRIVATE	56%	87%	44%
PUBLIC	52%	83%	44%

TABLE 6-9
RESEARCH FUNCTION OF ACADEMIC RESEARCH EQUIPMENT THAT IS USED FOR RESEARCH
BUT IS NOT STATE-OF-THE-ART
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

	NUMBER AND PERCENT OF NON STATE-OF-THE-ART SYSTEMS		
		RESEARCH FUNCTION	
	TOTAL	THE MOST ADVANCED INSTRUMENT TO WHICH ITS USERS HAVE ACCESS	USED FOR RESEARCH, BUT MORE ADVANCED EQUIPMENT IS AVAILABLE
TOTAL, SELECTED FIELDS	13991 100%	5787 41%	8204 59%
SUBFIELD OF RESEARCH			
BIOCHEMISTRY	3300 100%	1236 37%	2064 63%
MICROBIOLOGY	1209 100%	488 40%	721 60%
MOLECULAR/CELLULAR BIOLOGY	1990 100%	746 38%	1243 62%
PHYSIOLOGY/BIOPHYSICS	1818 100%	742 41%	1076 59%
ANATOMY	314 100%	179 57%	136 43%
PATHOLOGY	601 100%	290 48%	311 52%
PHARMACOLOGY/TOXICOLOGY	1324 100%	478 36%	846 64%
ZOOLOGY/ENTOMOLOGY	298 100%	181 61%	117 39%
BOTANY	330 100%	142 43%	188 57%
FOOD AND NUTRITION	259 100%	148 57%	111 43%
BIOLOGY, GENERAL AND N.E.C.	819 100%	411 50%	408 50%
MEDICAL SCIENCES/DEPTS MED	1413 100%	492 35%	922 65%
INTERDISCIPLINARY, N.E.C.	114 100%	54 47%	60 53%
FIELD AND SETTING			
BIOLOGICAL SCIENCES, TOTAL	11785 100%	4995 42%	6790 58%
GRADUATE SCHOOLS	4739 100%	2009 42%	2729 58%
MEDICAL SCHOOLS	7047 100%	2995 43%	4052 57%
DEPARTMENT OF MEDICINE	2206 100%	792 36%	1413 64%
INSTITUTION CONTROL			
PRIVATE	4511 100%	1802 40%	2709 60%
PUBLIC	9479 100%	3985 42%	5494 58%

Figure 6-3 Percent of Academic Research Equipment That Is in Excellent Working Condition, by Year of Purchase Biological and Medical Sciences-



The percentage drops for successive three-year periods to 21 percent for those purchased from 1969 to 1971.

A small rise to 30 percent occurs for instruments 14 years and older. This small rise may be explained by another factor underlying the age-condition relationship. As shown in Figure 6-2, the proportion of instruments in active use decreases with age. Instruments that are in poor condition are routinely removed from use and disposed of, so that an ever-decreasing number of older instruments are retained in the laboratories. Thus, only 6 percent of all instruments in use are more than fifteen years old. Undoubtedly, these are the instruments that have been maintained sufficiently well to leave them in at least average working condition. Technological obsolescence is probably not a consideration for the functions that these instruments perform.

State-of-the-art systems, recently acquired for the most part, had 85 percent in excellent working condition. By contrast, only 44 percent of the non-state-of-the-art systems were rated as being in excellent condition. These other in-use systems constitute nearly 80 percent of the systems in active use.

By itself, the existence of a substantial amount of non-state-of-the-art research equipment is not a problem. Even the best-equipped research facilities would be expected to have such equipment -- for use in routine analyses, as backups for more advanced instruments, etc. Non-state-of-the-art equipment is a problem only in situations where its users do not have access to more advanced equipment when needed. Table 6-6 shows that this problem situation is not uncommon: nearly half (41%) of all non-state-of-the-art instrument systems in research use in the fields surveyed are the most advanced instruments of their kind to which their research users have access.

Among subfields, there is relatively little variation in the percent of instruments in excellent working condition. However, there is considerable variation in the percent of non-state-of-the-art instruments for which more advanced instruments are available. The subfields that had the largest proportions of more advanced instruments available (over 60 percent) were medical sciences, biochemistry, and molecular/ cellular biology. The subfields that had to rely more than half the time on non-state-of-the-art equipment as the most advanced available were anatomy, zoology, and food/nutrition. Departments of medicine had advanced instruments available when needed more frequently than did the biological sciences.

Other fields of science reported approximately the same proportions of instruments in excellent working condition as the biological sciences (Appendix Table A-9). However, biology had somewhat higher proportions of instruments that were not state-of-the-art, for which more advanced equipment was available when needed, than did most other fields (Appendix Table A-10).

The adequacy of research instruments in the biological sciences must be questioned when half of the equipment is in some degree of disrepair (i.e., is in less than excellent working condition and when nearly half of instruments that are not state-of-the-art are the most advanced to which investigators have access -- especially when these other instruments constitute nearly 80 percent of all equipment in use. Is the research community well served by so widespread a lack in capabilities for front-line research? Granted that not every procedure in biological research requires the most advanced instrumentation, a number of disciplines appear to have too little advanced equipment compared to the subfields that are best endowed.

6.3 Summary

For the subfields of research included in this study, 44 percent of the instrument systems in the 1983 national stock were from one to five years old, while 27 percent were over 10 years old. However, for the subset of systems actively used for research in 1983, the proportion of systems in the age range 1-5 years was a much larger 50 percent, and those over 10 years old constituted only 22 percent. Departments of medicine had a higher proportion of the newer instruments than the biological sciences. They also replaced instruments more quickly.

Private institutions had proportionately more of the newer instruments than public institutions and fewer of the older ones. Compared with other fields of science in the survey, instruments in the biological sciences tended to be somewhat older.

The percentage of systems acquired in years prior to 1983 that were still considered state-of-the-art in 1983 fell off sharply with increasing age of the instrument. Of those purchased in 1983, 50 percent were considered state-of-the-art. However, only 37 percent of those purchased two years earlier, in 1981, were still considered state-of-the-art. Six-year-old instruments were classified as state-of-the-art only 13 percent of the time. Evidently, the life span for classification as state-of-the-art is very short.

The age distribution of state-of-the-art instruments dropped off very sharply; however, for their instruments in active research use that were not classed as state-of-the-art there was a more moderate decline in age distribution, from 40 percent of those from 1 to 5 years old to 27 percent for those over 10 years old.

An important issue is how well research equipment is actually performing. About half of the instrument systems were considered to be in excellent working condition -- 85 percent for state-of-the-art instruments but only 41 percent for other in-use instruments. As would be expected, there was a strong relationship between age of instruments and their working condition, with 78 percent of those from 1 to 3 years old in excellent condition but only 21 percent of those between 11 and 13 years old. A small number of instruments even older than that were still performing adequately in their presumably routine functions.

Systems that were not state-of-the-art accounted for nearly 80 percent of all instruments in actual research use. Such instruments play an important role in research laboratories when state-of-the-art equipment is not required. However, when research investigators do not have access to more advanced equipment, thus having to "make do" with older, less capable instruments, they face an obstacle in their attempt to engage in more sophisticated research. This is apparently the situation generally in some subfields of research, and in other subfields in at least a large proportion of laboratories. Overall, nearly half of the non-state-of-the-art instruments in the biological sciences were the most advanced to which investigators had access. For departments of medicine, that percentage was closer to one-third. To the extent that these obstacles to instrument performance and capability appear, the entire research effort in the biological sciences is hampered.

7. FUNDING OF EQUIPMENT IN ACTIVE RESEARCH USE

Two questions of interest concerning the funding of research equipment are: (1) where do the funds come from to purchase equipment in the biological and medical sciences; and (2) aside from purchasing equipment, what other means are commonly employed to acquire equipment. It is not possible to determine from this study if any changes over time have occurred. However, the data do provide a baseline against which to measure future changes.

7.1 Means of Acquiring Research Equipment

Both the numbers of instrument systems and the costs of these systems (Tables 7-1 and 7-2) indicate that the only significant method of procurement was purchasing new equipment. Ninety-four percent of the systems, with a total cost of 95 percent of all funds spent, were obtained this way. Locally built systems scarcely appeared as a factor in the biological and medical sciences. There was practically no donated equipment, and the purchase of used items was negligible.

7.2 Funding Sources for Research Equipment

Federal agencies and non-Federal sources each provided one-half of the money for research equipment. Figure 7-1 illustrates the amounts contributed by the several sources. More details are provided in Table 7-3, which also reveals that the departments of medicine did not follow the funding pattern of the biological sciences: departments of medicine obtained their funds in nearly a two-to-one ratio from non-Federal sources.

TABLE 7-1
MEANS OF ACQUISITION OF ACADEMIC RESEARCH EQUIPMENT
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

	NUMBER AND PERCENT OF IN-USE SYSTEMS							
		MEANS OF ACQUISITION						
					DONATED			
	TOTAL	PUR-CHASED NEW	LOCALLY BUILT	PUR-CHASED USED	NEW	USED	GOV'T SURPLUS	OTHER
TOTAL	17829 100%	16734 94%	78 -	540 3%	26 -	38 -	43 -	370 2%
SUBFIELD OF RESEARCH								
BIOCHEMISTRY	4095 100%	3874 95%	4 -	106 3%	0	17 -	0	94 2%
MICROBIOLOGY	1443 100%	1367 95%	2 -	34 2%	4 -	12 1%	9 1%	15 1%
MOLECULAR/CELLULAR BIOLOGY	2818 100%	2600 95%	2 -	79 3%	0	0	0	36 2%
PHYSIOLOGY/BIOPHYSICS	2314 100%	2095 91%	22 1%	86 4%	6 -	6 -	21 1%	78 3%
ANATOMY	430 100%	386 90%	0	35 8%	0	0	0	10 2%
PATHOLOGY	773 100%	729 94%	0	22 3%	9 1%	0	0	13 2%
PHARMACOLOGY/TOXICOLOGY	1760 100%	1660 94%	15 1%	52 3%	0	0	9 -	25 1%
ZOOLOGY/ENTOMOLOGY	422 100%	386 92%	6 1%	23 5%	2 -	0	0	5 1%
BOTANY	436 100%	422 97%	0	8 2%	0	0	4 1%	2 -
FOOD AND NUTRITION	347 100%	325 94%	2 -	17 5%	0	3 1%	0	0
BIOLOGY, GENERAL AND N.E.C.	993 100%	920 93%	16 2%	40 4%	3 -	0	0	15 1%
MEDICAL SCIENCES/DEPTS MED	1784 100%	1690 95%	0	35 2%	2 -	0	0	56 3%
INTERDISCIPLINARY, N.E.C.	191 100%	178 93%	9 5%	4 2%	0	0	0	0
FIELD AND SETTING								
BIOLOGICAL SCIENCES, TOTAL	15008 100%	14130 94%	78 1%	451 3%	20 -	36 -	43 -	250 2%
GRADUATE SCHOOLS	6074 100%	5712 94%	38 1%	210 3%	3 -	13 -	10 -	89 1%
MEDICAL SCHOOLS	8933 100%	8418 94%	40 -	241 3%	17 -	24 -	32 -	162 2%
DEPARTMENTS OF MEDICINE	2821 100%	2604 92%	0	90 3%	6 -	2 -	0	119 4%
INSTITUTION CONTROL								
PRIVATE	6132 100%	5811 95%	41 1%	156 3%	10 -	23 -	9 -	83 1%
PUBLIC	11697 100%	10923 93%	37 -	384 3%	16 -	16 -	34 -	287 2%

TABLE 7-3
ACQUISITION COST OF ACADEMIC RESEARCH EQUIPMENT, BY MEANS OF ACQUISITION
(INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983): BIOLOGICAL AND MEDICAL SCIENCES

(DOLLARS IN MILLIONS)

	ACQUISITION COST AND PERCENT OF COSTS OF IN-USE SYSTEMS							
		MEANS OF ACQUISITION						
					DONATED			
	TOTAL	PURCHASED NEW	LOCALLY BUILT	PURCHASED USED	NEW	USED	GOV'T SURPLUS	OTHER
TOTAL	$472.9 100%	$448.2 95%	$6.4 1%	$14.9 3%	$.6 -	$.1 -	$.1 -	$1.8 -
SUBFIELD OF RESEARCH								
BIOCHEMISTRY	95.1 100%	92.3 97%	.1 -	2.2 2%	0	0	0	.5 1%
MICROBIOLOGY	36.4 100%	35.2 96%	0 -	.7 2%	0	.1 -	0 -	.4 1%
MOLECULAR/CELLULAR BIOLOGY	81.8 100%	77.4 95%	1.0 1%	3.1 3%	0	0	0	.2 -
PHYSIOLOGY/BIOPHYSICS	68.2 100%	63.5 93%	2.0 3%	2.2 3%	.2 -	0	0	.3 1%
ANATOMY	14.9 100%	14.1 95%	0	.8 5%	0	0	0	0
PATHOLOGY	24.7 100%	23.7 96%	0	.6 2%	.5 2%	0	0	0
PHARMACOLOGY/TOXICOLOGY	38.6 100%	37.6 97%	.4 1%	.5 1%	0	0	0	0
ZOOLOGY/ENTOMOLOGY	10.7 100%	9.9 92%	.3 3%	.4 4%	0	0	0	.1 1%
BOTANY	10.7 100%	10.5 98%	0	.2 2%	0	0	0 -	0
FOOD AND NUTRITION	7.7 100%	7.2 93%	.1 2%	.4 5%	0	0	0	0
BIOLOGY, GENERAL AND N.E.C.	34.2 100%	31.0 91%	2.0 6%	1.2 3%	0	0	0	0 -
MEDICAL SCIENCES/DEPTS NEC	46.7 100%	43.1 92%	0	3.5 8%	0	0	0	.1 -
INTERDISCIPLINARY, N.E.C.	6.9 100%	6.5 94%	.3 4%	.2 2%	0	0	0	0
FIELD AND SETTING								
BIOLOGICAL SCIENCES, TOTAL	403.7 100%	384.6 95%	6.4 2%	10.2 3%	.6 -	.1 -	.1 -	1.3 -
GRADUATE SCHOOLS	153.8 100%	144.8 94%	3.3 2%	4.9 3%	0	0	0 -	.5 -
MEDICAL SCHOOLS	249.9 100%	239.7 96%	3.1 1%	5.3 2%	.6 -	.1 -	0 -	.8 -
DEPARTMENTS OF MEDICINE	69.1 100%	63.8 92%	0	4.7 7%	0	0	0	.6 1%
INSTITUTION CONTROL								
PRIVATE	180.5 100%	171.3 95%	4.5 2%	3.7 2%	.2 -	.1 -	0	.6 -
PUBLIC	292.4 100%	276.8 95%	1.9 1%	11.2 4%	.5 -	0	.1 -	1.4 -

Figure 7-1. Sources of Funds for Academic Research Equipment in Active Research Use Biological and Medical Sciences

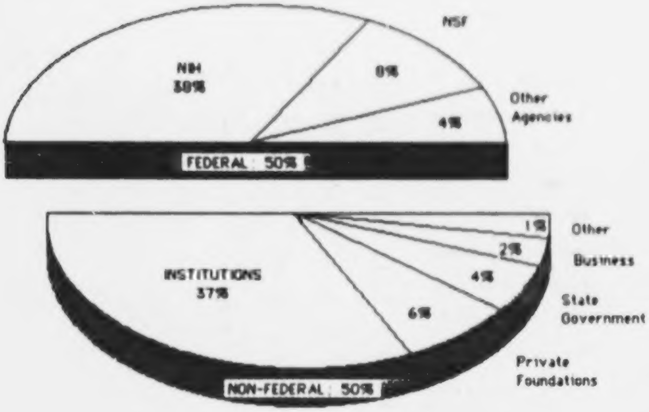


TABLE 7-3
SOURCES OF FUNDS FOR ACADEMIC RESEARCH EQUIPMENT, BY FIELD AND SETTING
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

(DOLLARS IN MILLIONS)

	FUNDS CONTRIBUTED AND PERCENT OF FUNDS			
		FIELD AND SETTING		
		BIOLOGICAL SCIENCES		
	TOTAL	GRADUATE SCHOOLS	MEDICAL SCHOOLS	DEPARTMENTS OF MEDICINE
TOTAL, ALL SOURCES	$446.8 100%	$148.3 100%	$232.0 100%	$66.6 100%
FEDERAL SOURCES, TOTAL	221.4 50%	75.9 51%	120.0 52%	25.6 38%
NSF	33.6 8%	22.3 15%	10.9 5%	.4 1%
NIH	171.0 38%	46.4 31%	102.0 44%	22.6 34%
DOD	4.6 1%	1.0 1%	1.8 1%	1.8 3%
OTHER FEDERAL SOURCES	12.2 3%	6.1 4%	5.3 2%	.8 1%
NON-FEDERAL SOURCES, TOTAL	225.4 50%	72.4 49%	112.0 48%	41.0 62%
INSTITUTION OR DEPARTMENT FUNDS	165.6 37%	47.2 32%	86.9 37%	31.5 47%
STATE GRANT/APPROPRIATION	18.4 4%	11.4 8%	6.0 3%	1.0 1%
PRIVATE NONPROFIT FOUNDATION	27.0 6%	7.3 5%	14.0 6%	5.7 9%
BUSINESS OR INDUSTRY	7.7 2%	4.5 3%	2.4 1%	.7 1%
OTHER NON-FEDERAL SOURCES	6.6 1%	1.9 1%	2.6 1%	2.1 3%

NIH was the principal source of Federal funds for equipment. Graduate schools obtained 31 percent of their equipment funds from NIH, while the biological sciences in the medical schools secured 44 percent. For departments of medicine, NIH was the only significant Federal source. NSF contributed 15 percent of the graduate schools' equipment funds, but only 5 percent of the medical schools'.

Institutional funds were reported to be the principal source for non-Federal moneys, with 32 percent of the graduate schools' equipment funds, 37 percent of the medical schools', and nearly half of all funds for departments of medicine. The meaning of institutional funds in this context is not entirely clear. The research investigators who supplied information on the funding sources for the instruments for which they were responsible could not be expected to know the sources of money supplied by the institution unless it had been earmarked by a specific donor. It is possible that some of the institution's funds originated with the Federal government through programs such as the Biomedical Research Support Grants, which are disbursed through a formula based on an institution's total research funding and intended to provide unrestricted support to biomedical research. Another possible source is the indirect cost portion of research grants, which may be redirected by the institution into equipment funding or, in the case of some States that receive the indirect costs for state-supported institutions, routed back to the institution for the same purpose. Technically, these can be considered to be institutional funds, although they do not originate from within the institution's own resources. To what extent the total that was designated institutional funding contained this re-routed Federal funding -- or similar non-Federal unrestricted grants -- cannnot be determined from these data.

Another source that may be included in the institutional fund category for medical schools, and which may also account for some of the differential in equipment funding between graduate and medical schools, is the revenue generated from clinical activities of the faculty. No estimate can be given for that element from the data in this survey.

Besides the institutional funds, no matter what their origins may have been, other non-Federal sources played minor roles in equipment funding. State funds constituted 3 percent of equipment money for medical schools, but 8 percent for graduate schools (which had a considerably higher proportion of public institutions). Private nonprofit foundations contributed about 5 percent of equipment spending for the biological sciences and 9 percent for departments of medicine. Business and industry, a source that might relieve the Federal government of some of the burden for research support, contributed only 2 percent of all equipment funds in the biological and medical sciences.

Private institutions fared a little better proportionately from the Federal government than did public institutions. They received 53 percent of their equipment funds from Federal agencies compared with the 47 percent received by public institutions (Table 7-4). The average Federal contribution for research equipment to 93 private institutions was $992,000 per institution, whereas the 156 public institutions averaged $828,000. Institutional funds, however, were about the same for private and public universities and medical schools, both in terms of percentage of funds and in average dollars per institution. The only other significant difference in funding sources was the 7 percent of the total contributed by state governments to public institutions compared to practically no State government contributions to private institutions.

TABLE 7-4
SOURCES OF FUNDS FOR ACADEMIC RESEARCH EQUIPMENT, BY INSTITUTIONAL CONTROL
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

(DOLLARS IN MILLIONS)

	-FUNDS CONTRIBUTED AND PERCENT OF FUNDS-		
		-CONTROL OF INSTITUTION--	
	TOTAL	PRIVATE INSTITUTIONS	PUBLIC INSTITUTIONS
TOTAL, ALL SOURCES	$446.8 100%	$172.7 100%	$274.1 100%
FEDERAL SOURCES, TOTAL	221.4 50%	92.3 53%	129.1 47%
NSF	33.6 8%	11.8 7%	21.8 8%
NIH	171.5 38%	71.7 42%	99.8 36%
DOD	4.0 1%	3.1 2%	.9 -
OTHER FEDERAL SOURCES	12.3 3%	5.7 3%	6.6 2%
NON-FEDERAL SOURCES, TOTAL	225.4 50%	80.4 47%	145.0 53%
INSTITUTION OR DEPARTMENT FUNDS	165.6 37%	61.7 36%	103.9 38%
STATE GRANT/APPROPRIATION	18.4 4%	.6 -	17.9 7%
PRIVATE NONPROFIT FOUNDATION	27.0 6%	12.5 7%	14.5 5%
BUSINESS OR INDUSTRY	7.7 2%	4.0 2%	3.7 1%
OTHER NON-FEDERAL SOURCES	6.6 1%	1.7 1%	4.9 2%

The funding sources for biological sciences are compared with those for other fields in Appendix Tables A-11 and A-12. In A-11, the proportions of funds each field received from the various sources are summarized, and in A-12 the distribution of each source's funds by field is shown. Table A-11 shows that the biological sciences received a larger portion of their equipment funds from Federal sources than any other surveyed field except the physical and materials sciences. By far the largest part of the Federal funds for the biological sciences came from NIH. Each of the other fields had its own pattern of funding sources, none of which resembled that for the biological sciences. For example, about half of the funds for agricultural sciences came from the institutions themselves, whereas all other fields had much lower proportions of funding from the institutions. Business and industry were not much of a factor except for computer science and, perhaps, environmental sciences.

Appendix Table A-12 indicates the principal interest of each Federal agency for the surveyed fields of science, as well as the distribution of funds from all of the other sources. NIH, for example, distributed almost all of its equipment funds to the biological sciences, with nearly all of the remainder to the physical sciences. NSF, on the other hand, granted about half of its funds to the physical sciences and about a sixth each to engineering and the biological sciences. Department of Agriculture funds went mostly to agricultural sciences. The next highest level of Department of Agriculture funding went to the biological sciences in graduate schools. While more of the university funds went to the biological sciences than to any other field, equipment funds from that source are broadly distributed among all fields, roughly in proportion to their total funding.

Another perspective concerning funding is shown in Table 7-5, which illustrates the pattern of funding from various sources by system cost categories. The Federal sources accounted for 50 percent of all equipment funding, as did the non-Federal sources. However, 55 percent of funding for equipment costing less than $25,000 came from Federal sources, with the remaining 45 percent coming from non-Federal sources. Conversely, 46 percent of the funding for instruments costing $75,000 or more was purchased with Federal money, compared to 54 percent from non-Federal money.

NIH, which contributed 38 percent of all equipment funding, provided 47 percent of the funds for instruments costing under $25,000 and 28 percent for those costing $75,000 or more. NSF showed the reverse pattern, providing 8 percent of all equipment funding but 5 percent of the funds for instruments costing less than $25,000 and 12 percent for those costing $75,000 or more. Institutional funds were also skewed toward the more expensive items, with 31 percent for all instruments under $25,000 and 41 percent for those costing $75,000 or more.

Federal involvement as a source of funding is examined in Table 7-6. For example, 42 percent of the equipment items were funded without any Federal money, while 48 percent were funded exclusively with Federal funds. Wide variations among the subfields occurred, ranging from 59 percent of the biochemistry items receiving full Federal funding to 36 percent of microbiology instruments to 13 percent for food/nutrition. Non-Federal funding was the dominant source for medical sciences and food/nutrition, along with pathology and microbiology. Shared funding was used to purchase only 10 percent of all instrument systems. The percentage of shared costs was at a low level for all subfields, with medical sciences the lowest of all at 4 percent.

TABLE 7-3
SOURCES OF FUNDS FOR ACADEMIC RESEARCH EQUIPMENT, BY SYSTEM COST RANGE
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

(DOLLARS IN MILLIONS)

	------FUNDS CONTRIBUTED AND PERCENT OF FUNDS-------			
		-------SYSTEM ACQUISITION COST--------		
	TOTAL	UNDER $25,000	$25,000-$74,999	$75,000 OR MORE
TOTAL, ALL SOURCES	$446.8 100%	$184.7 100%	$143.0 100%	$119.1 100%
FEDERAL SOURCES, TOTAL	221.4 50%	102.5 55%	64.6 45%	54.3 46%
NSF	33.6 8%	10.0 5%	8.9 6%	14.8 12%
NIH	171.5 38%	86.6 47%	51.7 36%	33.2 28%
DOD	4.0 1%	1.7 1%	1.2 1%	1.1 1%
OTHER FEDERAL SOURCES	12.3 3%	4.2 2%	2.9 2%	5.2 4%
NON-FEDERAL SOURCES, TOTAL	225.4 50%	82.2 45%	78.4 55%	64.8 54%
INSTITUTION OR DEPARTMENT FUNDS	165.6 37%	57.8 31%	59.5 42%	48.3 41%
STATE GRANT/APPROPRIATION	18.4 4%	8.4 5%	6.6 5%	3.4 3%
PRIVATE NONPROFIT FOUNDATION	27.0 6%	11.1 6%	7.7 5%	8.1 7%
BUSINESS OR INDUSTRY	7.7 2%	2.3 1%	3.2 2%	2.3 2%
OTHER NON-FEDERAL SOURCES	6.6 1%	2.6 1%	1.3 1%	2.7 2%

TABLE 7-6
FEDERAL INVOLVEMENT IN FUNDING OF ACADEMIC RESEARCH EQUIPMENT
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

	------NUMBER AND PERCENT OF SYSTEMS------			
		-FEDERAL FUNDING INVOLVEMENT-		
	TOTAL	NO FUNDING	PARTIAL FUNDING	100% FUNDING
TOTAL	16334 100%	6858 42%	1704 10%	7772 48%
SUBFIELD OF RESEARCH				
BIOCHEMISTRY	3742 100%	1081 29%	467 12%	2195 59%
MICROBIOLOGY	1351 100%	682 50%	178 13%	491 36%
MOLECULAR/CELLULAR BIOLOGY	2615 100%	1158 44%	240 9%	1217 47%
PHYSIOLOGY/BIOPHYSICS	2181 100%	815 37%	255 12%	1111 51%
ANATOMY	371 100%	154 41%	38 10%	179 48%
PATHOLOGY	715 100%	377 53%	47 7%	291 41%
PHARMACOLOGY/TOXICOLOGY	1589 100%	665 42%	124 8%	800 50%
ZOOLOGY/ENTOMOLOGY	399 100%	172 43%	42 11%	184 46%
BOTANY	422 100%	143 34%	61 14%	218 52%
FOOD AND NUTRITION	326 100%	250 77%	33 10%	43 13%
BIOLOGY, GENERAL AND N.E.C.	815 100%	335 41%	124 15%	356 44%
MEDICAL SCIENCES/DEPTS MED	1632 100%	946 58%	65 4%	622 38%
INTERDISCIPLINARY, N.E.C.	175 100%	81 46%	31 18%	63 36%
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	13785 100%	5542 40%	1604 12%	6640 48%
GRADUATE SCHOOLS	5729 100%	2363 41%	792 14%	2574 45%
MEDICAL SCHOOLS	8056 100%	3178 39%	812 10%	4066 50%
DEPARTMENTS OF MEDICINE	2548 100%	1317 52%	100 4%	1132 44%
INSTITUTION CONTROL				
PRIVATE	5733 100%	2289 40%	426 7%	3019 53%
PUBLIC	10600 100%	4569 43%	1278 12%	4753 45%

The summary totals in Table 7-6 reveal a considerable difference between the extent of non-Federal funding for the biological sciences and departments of medicine. For the latter, 52 percent of their instruments were completely funded by non-Federal sources, while for the biological sciences only 40 percent were completely dependent on those sources. In private institutions, 53 percent of the instruments received total funding from Federal agencies, compared with 45 percent for public institutions.

About half of the instruments in the biological sciences were completely funded by Federal sources, the same proportion as found for physical sciences; however, the physical sciences had partial funding from Federal sources about twice as often as biology (Appendix Table A-13). Agricultural science instruments rarely had any Federal funding, but almost all those in materials science had at least partial Federal funding.

7.3 Summary

Almost all instrument systems in the biological sciences and departments of medicine were purchased new. No other means of acquisition played a significant role.

Funding sources for the biological sciences in graduate schools differed from those in medical schools. While both received about half of their funds from Federal sources -- and NIH was by far the largest Federal contributor to both settings -- NSF contributed three times as much to the graduate schools as it did to medical schools. Among the non-Federal sources, the institutions were the major contributors, with a slightly higher proportion of institutional funds going to medical schools than to graduate schools. Institutional funds, however, contain an undetermined component of money originating from Federal sources.

Funds from the state were a minor factor, but they went mostly to graduate schools. Departments of medicine, however, received 62 percent of their funding from non-Federal sources, three-fourths of that being from their institutions. Private institutions received a higher proportion of their equipment funds from Federal sources than did the public institutions.

Federal sources as a whole funded a larger percentage of instruments costing under $25,000 than did non-Federal sources, which in turn funded a larger percentage of those costing over $25,000. The funds granted by NIH were used for instruments costing less than $25,000, far more than for those costing $75,000 and more. The reverse was true for NSF's funds.

Private institutions had a higher percentage of instruments completely funded by Federal sources when compared with public institutions.

8. LOCATION AND USE OF ACADEMIC RESEARCH EQUIPMENT

Questions have been raised periodically concerning the extent to which research equipment in academic laboratories is available to qualified research investigators in other laboratories. Is sharing of expensive instrument systems a common practice, or do academic investigators tend to duplicate desirable instruments even though the equipment may lie unused within their own laboratories for considerable periods of time?

The present survey cannot answer all of these questions; the need for similar instruments in separate laboratories is a matter for local evaluation of how best to use the time and effort of skilled research teams. Nevertheless, many institutions have departmental laboratories where commonly used equipment is shared by most investigators and their staff members. In this chapter, data are presented on the location of equipment -- whether in individual investigators' laboratories or in shared facilities -- and on how many research personnel use instruments in each type of facility.

8.1 Location of Equipment

In the biological sciences, for both graduate and medical schools, about 65 percent of all equipment was located in within-department laboratories of individual principal investigators (P.I.s) (Table 8-1). For departments of medicine, the comparable number was 70 percent. Almost all of the remaining instrument systems were in department-managed common laboratories, with about 3 percent -- less for departments of medicine -- in nondepartmental instrumentation facilities and 1 percent in

TABLE 8-1
LOCATION OF ACADEMIC RESEARCH EQUIPMENT
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

	NUMBER AND PERCENT OF SYSTEMS		
	FIELD AND SETTING		
	BIOLOGICAL SCIENCES		
	GRADUATE SCHOOLS	MEDICAL SCHOOLS	DEPARTMENTS OF MEDICINE
TOTAL, ALL LOCATIONS	6069 100%	8912 100%	2810 100%
WITHIN DEPARTMENT LAB OF INDIVIDUAL PRINCIPAL INVESTIGATORS	3930 65%	5692 64%	1962 70%
SHARED-ACCESS FACILITIES, TOTAL	2139 35%	3219 36%	848 30%
NATIONAL, REGIONAL, OR INTER-UNIVERSITY INSTRUMENTATION FACILITY	48 1%	56 1%	54 2%
NON-DEPARTMENTAL RESEARCH FACILITY	202 3%	324 4%	37 1%
DEPARTMENT-MANAGED COMMON LAB	1860 31%	2824 32%	686 24%
OTHER	29 -	16 -	71 3%

national or regional facilities. For convenience, these latter three locations are collectively referred to as inherently shared-access facilities.

Compared with other fields of science (Appendix Table A-14), the location pattern for the biological sciences agrees most closely with those in agriculture and the physical sciences. The environmental sciences and engineering each had about half their systems in P.I.-controlled laboratories. In the remaining fields, nondepartmental facilities played a more prominent role.

Table 8-2 displays the percentage of systems in shared-access facilities by subfield of research and by state-of-the-art status. About 35 percent of both state-of-the-art and other in-use systems were in shared-access facilities. Several subfields had about 30 percent in shared facilities: biochemistry, molecular/cellular biology, physiology/biophysics, pharmacology/toxicology, and zoology. The other subfields ranged upward to as high as 50 percent. In a majority of the subfields it appears that state-of-the-art instruments were somewhat less likely to be in shared facilities than were other in-use instruments.

In Table 8-3, the proportions of instrument systems in shared-access facilities are presented within cost categories. Of systems costing between $10,000 and $24,999, only 31 percent were in shared facilities, whereas 63 percent of those costing between $75,000 and $1,000,000 were in shared facilities.

In the biological sciences, graduate schools and medical schools had the same overall proportions of instruments in shared-access facilities, yet 71 percent of the graduate school instruments in the top cost category were in such locations, compared

TABLE 8-8
PERCENT OF ACADEMIC RESEARCH EQUIPMENT LOCATED IN SHARED-ACCESS FACILITIES,
BY RESEARCH STATUS
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

	PERCENT OF SYSTEMS IN SHARED-ACCESS FACILITIES		
		---1983 RESEARCH STATUS----	
	TOTAL	STATE-OF-THE-ART SYSTEMS	OTHER SYSTEMS RESEARCH USE
TOTAL	35%	34%	35%
SUBFIELD OF RESEARCH			
BIOCHEMISTRY	29%	25%	30%
MICROBIOLOGY	48%	54%	46%
MOLECULAR/CELLULAR BIOLOGY	31%	31%	31%
PHYSIOLOGY/BIOPHYSICS	27%	29%	27%
ANATOMY	49%	42%	53%
PATHOLOGY	40%	32%	42%
PHARMACOLOGY/TOXICOLOGY	30%	31%	30%
ZOOLOGY/ENTOMOLOGY	28%	26%	29%
BOTANY	44%	23%	51%
FOOD AND NUTRITION	47%	44%	48%
BIOLOGY, GENERAL AND N.E.C.	53%	46%	54%
MEDICAL SCIENCES/DEPTS MED	39%	46%	37%
INTERDISCIPLINARY, N.E.C.	41%	40%	42%
FIELD AND SETTING			
BIOLOGICAL SCIENCES, TOTAL	36%	33%	36%
GRADUATE SCHOOLS	35%	31%	36%
MEDICAL SCHOOLS	36%	35%	36%
DEPARTMENTS OF MEDICINE	30%	34%	29%
INSTITUTION CONTROL			
PRIVATE	31%	34%	31%
PUBLIC	37%	34%	37%

TABLE 8-3
PERCENT OF ACADEMIC RESEARCH EQUIPMENT LOCATED IN SHARED-ACCESS FACILITIES, BY SYSTEM COST
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

	PERCENT OF SYSTEMS IN SHARED-ACCESS FACILITIES			
		SYSTEM PURCHASE COST		
	TOTAL	$10,000-$24,999	$25,000-$74,999	$75,000-$1,000,000
TOTAL	35%	31%	41%	63%
SUBFIELD OF RESEARCH				
BIOCHEMISTRY	29%	27%	33%	45%
MICROBIOLOGY	48%	45%	56%	61%
MOLECULAR/CELLULAR BIOLOGY	31%	27%	33%	74%
PHYSIOLOGY/BIOPHYSICS	27%	24%	32%	46%
ANATOMY	49%	37%	63%	70%
PATHOLOGY	40%	24%	64%	68%
PHARMACOLOGY/TOXICOLOGY	30%	29%	33%	41%
ZOOLOGY/ENTOMOLOGY	28%	21%	39%	53%
BOTANY	44%	40%	42%	100%
FOOD AND NUTRITION	47%	46%	49%	50%
BIOLOGY, GENERAL AND N.E.C.	53%	46%	57%	93%
MEDICAL SCIENCES/DEPTS MED	39%	33%	49%	66%
INTERDISCIPLINARY, N.E.C.	41%	38%	46%	46%
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	36%	32%	41%	64%
GRADUATE SCHOOLS	35%	32%	39%	71%
MEDICAL SCHOOLS	36%	32%	41%	61%
DEPARTMENTS OF MEDICINE	30%	25%	43%	58%
INSTITUTION CONTROL				
PRIVATE	31%	28%	35%	57%
PUBLIC	37%	32%	44%	67%

with 61 percent for medical schools. Public institutions had somewhat higher proportions in shared-access facilities across all cost categories than private institutions.

Older instruments were more frequently located in shared-access facilities (Table 8-4). Of those over 10 years old, 41 percent were in such locations, compared to 32 percent of those between 1 and 5 years old. This trend was apparent in 10 of the 13 subfields. It was true also for both private and public institutions.

8.2 Availability for General Purpose Use

About 17 percent of all research instruments in the fields surveyed were dedicated for use in a particular experiment or series of experiments (Table 8-5). About one-third of these dedicated instruments had been physically modified in some way to make them suitable for their intended use. The rest were reserved intact for the specified experiments, their calibration and position undisturbed by outside use. Physiology/biophysics had the largest proportion of dedicated systems, 32 percent.

The biological sciences had a smaller proportion of dedicated systems than most other fields of science (Appendix Table A-15). The physical sciences (39%), engineering (37%), environmental sciences (33%), and agricultural sciences (24%) all had larger proportions of their research equipment reserved for special purpose use than did the biological sciences.

TABLE 8-4
PERCENT OF ACADEMIC RESEARCH EQUIPMENT LOCATED IN SHARED-ACCESS FACILITIES
BY AGE OF SYSTEM
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

	PERCENT OF SYSTEMS IN SHARED-ACCESS FACILITIES			
		SYSTEM AGE (FROM YEAR OF PURCHASE)		
	TOTAL	1-5 YEARS (1979-83)	6-10 YEARS (1974-78)	OVER 10 YEARS (1973 OR BEFORE)
TOTAL	35%	32%	36%	41%
SUBFIELD OF RESEARCH				
BIOCHEMISTRY	29%	29%	24%	34%
MICROBIOLOGY	48%	37%	50%	64%
MOLECULAR/CELLULAR BIOLOGY	31%	26%	35%	37%
PHYSIOLOGY/BIOPHYSICS	27%	24%	28%	36%
ANATOMY	49%	47%	53%	50%
PATHOLOGY	40%	37%	38%	47%
PHARMACOLOGY/TOXICOLOGY	30%	30%	24%	39%
ZOOLOGY/ENTOMOLOGY	28%	22%	37%	44%
BOTANY	44%	31%	64%	57%
FOOD AND NUTRITION	47%	42%	48%	58%
BIOLOGY, GENERAL AND N.E.C.	53%	56%	31%	47%
MEDICAL SCIENCES/DEPTS MED	39%	37%	44%	38%
INTERDISCIPLINARY, N.E.C.	41%	38%	54%	19%
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	36%	32%	36%	43%
GRADUATE SCHOOLS	35%	31%	38%	41%
MEDICAL SCHOOLS	36%	33%	35%	44%
DEPARTMENTS OF MEDICINE	30%	30%	32%	29%
INSTITUTION CONTROL				
PRIVATE	31%	29%	33%	36%
PUBLIC	37%	33%	37%	43%

TABLE 8-9
EXPERIMENTAL ROLE OF ACADEMIC RESEARCH EQUIPMENT
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

	NUMBER AND PERCENT OF SYSTEMS			
		1983 EXPERIMENTAL ROLE		
		DEDICATED [1]		GENERAL
	TOTAL	MODIFIED	NOT MODIFIED	PURPOSE
TOTAL	17441	864	2035	14542
	100%	5%	12%	83%
SUBFIELD OF RESEARCH				
BIOCHEMISTRY	4019	171	349	3499
	100%	4%	9%	87%
MICROBIOLOGY	1449	30	45	1374
	100%	2%	3%	95%
MOLECULAR/CELLULAR BIOLOGY	2743	31	243	2469
	100%	1%	9%	90%
PHYSIOLOGY/BIOPHYSICS	2298	292	431	1574
	100%	13%	19%	68%
ANATOMY	439	12	74	353
	100%	3%	17%	80%
PATHOLOGY	758	13	65	680
	100%	2%	9%	90%
PHARMACOLOGY/TOXICOLOGY	1717	90	348	1279
	100%	5%	20%	73%
ZOOLOGY/ENTOMOLOGY	411	12	79	320
	100%	3%	19%	78%
BOTANY	412	16	41	355
	100%	4%	10%	86%
FOOD AND NUTRITION	327	21	47	259
	100%	6%	14%	79%
BIOLOGY, GENERAL AND N.E.C.	994	76	115	804
	100%	8%	12%	81%
MEDICAL SCIENCES/DEPTS MED	1707	129	167	1411
	100%	8%	10%	83%
INTERDISCIPLINARY, N.E.C.	177	11	30	136
	100%	6%	17%	77%
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	14724	639	1805	12280
	100%	4%	12%	83%
GRADUATE SCHOOLS	5937	188	581	5168
	100%	3%	10%	87%
MEDICAL SCHOOLS	8787	451	1224	7112
	100%	5%	14%	81%
DEPARTMENTS OF MEDICINE	2717	225	230	2262
	100%	8%	8%	83%
INSTITUTION CONTROL				
PRIVATE	5961	291	758	4912
	100%	5%	13%	82%
PUBLIC	11480	573	1277	9630
	100%	5%	11%	84%

[1] DEDICATED FOR USE IN A SPECIFIC EXPERIMENT OR SERIES OF EXPERIMENTS, AS DISTINGUISHED FROM GENERAL PURPOSE INSTRUMENTS. DEDICATED INSTRUMENT SYSTEMS MAY OR MAY NOT INVOLVE MODIFICATIONS: "ANY SPECIAL CALIBRATION, PROGRAMMING OR OTHER MODIFICATION WHICH RENDERED THE INSTRUMENT UNSUITABLE FOR GENERAL PURPOSE USE."

8.3 Annual Number of Research Users per Instrument System

An index of how widely academic research equipment is used is the mean annual number of users per instrument system. In Table 8-6 it is seen that the average instrument system in the biological sciences and departments of medicine was used by 10.9 researchers in 1983. This number varied among subfields, from a low of 8.0 users per system per year in zoology and 8.6 in medical sciences to a high of 14.2 for both microbiology and general biology. General purpose instruments had a mean of 11.8 users, in contrast to about 6.6 users for dedicated instruments.

As shown in the second part of Table 8-6, graduate schools had more users per instrument than did medical schools, and biological sciences as a whole had considerably more than departments of medicine. Private institutions had slightly more users per system than did public institutions, and state-of-the-art instruments were used by slightly more researchers than other in-use instruments. However, purchase cost showed the only noteworthy differential: instrument systems in the cost range of $75,000 to $1,000,000 had much larger mean numbers of users than did those in the two lower cost ranges. In all of these comparisons, general purpose instruments were more broadly used than were dedicated ones, as would be expected.

Appendix Table A-16 shows that the biological sciences, along with agricultural sciences, had fewer users per instrument than all other fields of science. The physical sciences, which had the same proportion of instruments in the laboratories of principal investigators as did the biological sciences (Appendix Table A-15), nevertheless had 15.5 users per instrument, noticably more than the biological sciences.

TABLE 8-6
MEAN NUMBER OF RESEARCH USERS OF ACADEMIC RESEARCH EQUIPMENT BY RESEARCH FUNCTION
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

	MEAN NUMBER OF RESEARCH USERS			
		1983 RESEARCH FUNCTION		
		DEDICATED (1)		GENERAL PURPOSE
	TOTAL	MODIFIED	NOT MODIFIED	
TOTAL	10.9	7.8	6.4	11.8
SUBFIELD OF RESEARCH				
BIOCHEMISTRY	11.0	4.9	6.5	11.8
MICROBIOLOGY	14.2	*	7.9	14.5
MOLECULAR/CELLULAR BIOLOGY	12.0	*	10.1	12.1
PHYSIOLOGY/BIOPHYSICS	9.2	6.7	4.6	10.9
ANATOMY	9.6	*	7.3	10.4
PATHOLOGY	11.7	*	12.4	11.0
PHARMACOLOGY/TOXICOLOGY	9.2	10.0	5.5	10.1
ZOOLOGY/ENTOMOLOGY	8.0	*	6.0	8.8
BOTANY	12.3	*	6.4	13.2
FOOD AND NUTRITION	11.1	*	3.5	12.3
BIOLOGY, GENERAL AND N.E.C.	14.2	5.0	6.2	16.1
MEDICAL SCIENCES/DEPTS MED	8.6	5.6	6.3	9.1
INTERDISCIPLINARY, N.E.C.	13.0	*	6.4	14.6
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	11.4	7.8	6.5	12.3
GRADUATE SCHOOLS	12.3	11.0	6.2	13.0
MEDICAL SCHOOLS	10.8	6.2	6.7	11.8
DEPARTMENTS OF MEDICINE	8.2	4.8	3.5	8.8
INSTITUTION CONTROL				
PRIVATE	11.3	7.2	7.0	12.1
PUBLIC	10.7	6.9	6.1	11.6
RESEARCH STATUS				
STATE OF THE ART	11.2	5.2	6.6	12.7
OTHER	10.8	7.8	6.3	11.5
PURCHASE COST				
$10,000-$24,999	10.3	5.7	3.9	11.2
$25,000-$74,999	11.2	8.4	7.7	11.8
$75,000-$1,000,000	10.1	11.7	12.0	19.9

* NUMBER OF CASES IN THE UNDERLYING SAMPLE WAS INSUFFICIENT FOR A RELIABLE ESTIMATE.

(1) DEDICATED FOR USE IN A SPECIFIC EXPERIMENT OR SERIES OF EXPERIMENTS, AS DISTINGUISHED FROM GENERAL PURPOSE INSTRUMENTS. DEDICATED INSTRUMENT SYSTEMS MAY OR MAY NOT INVOLVE MODIFICATIONS: "ANY SPECIAL CALIBRATION, PROGRAMMING OR OTHER MODIFICATION WHICH RENDERED THE INSTRUMENT UNSUITABLE FOR GENERAL PURPOSE USE."

Another approach to quantification of instrument usage is the extent to which instruments are used by researchers from outside the departments in which they are located. In Table 8-7, researchers are classified according to their origin: first being faculty or faculty-equivalent researchers from within the department; then graduate students, medical students, and postdoctorates from within the department; and then researchers from increasingly remote origins. Of course, individual instruments could be used by more than one category of user.

For all subfields, 95 percent of the instruments were used by faculty of the host department. In addition, 36 percent of these same instruments were used by researchers from other departments of the same institution, 10 percent were used by researchers from other universities, and 14 percent were used by nonacademic researchers. Eighty-two percent of all instruments were also used by graduate students, medical students, and postdoctorates within their own departments.

There was little variation among subfields in the percentage of instrument systems used by faculty from the host department. There was also little variation among subfields for percent of instruments used by graduate and medical students and postdoctorates, except for pathology and medical sciences, which had significantly lower percentages than other fields. For these two subfields, there is probably a relationship between the reduced usage of instruments and the lack of graduate students. Pathology, for example, had the smallest number of doctoral degrees awarded of all the subfields studied (Table 5-7). For medical sciences, the research was performed mostly in departments of medicine, which do not award graduate degrees. With the exception of microbiology, all of the major subfields had a little over 30 percent of their instruments used by researchers

TABLE 8-7
PERCENT OF ACADEMIC RESEARCH EQUIPMENT USED BY VARIOUS TYPES OF RESEARCH USERS
INSTRUMENT SYSTEMS IN RESEARCH USE IN 1983: BIOLOGICAL AND MEDICAL SCIENCES

	PERCENT OF IN-USE SYSTEMS USED IN 1983 BY:				
	FACULTY, THIS DEPT./ FACILITY	GRADUATE AND MEDICAL STUDENTS AND POST DOCS., THIS DEPT./ FACILITY	RESEARCHERS FROM OTHER DEPTS. THIS INSTITUTION	RESEARCHERS FROM OTHER UNIVERSITIES	NONACADEMIC RESEARCHERS
TOTAL	95.2%	82.5%	36.4%	9.6%	13.9%
SUBFIELD OF RESEARCH					
BIOCHEMISTRY	93.2%	84.2%	39.7%	8.3%	12.0%
MICROBIOLOGY	96.1%	86.3%	49.8%	5.9%	9.5%
MOLECULAR/CELLULAR BIOLOGY	97.4%	88.5%	32.1%	6.4%	19.7%
PHYSIOLOGY/BIOPHYSICS	95.9%	81.6%	33.8%	9.7%	8.2%
ANATOMY	96.6%	81.2%	31.6%	6.2%	10.3%
PATHOLOGY	97.0%	64.7%	29.4%	7.9%	7.1%
PHARMACOLOGY/TOXICOLOGY	92.9%	89.9%	33.4%	10.4%	16.2%
ZOOLOGY/ENTOMOLOGY	96.7%	86.7%	31.0%	8.0%	9.9%
BOTANY	97.0%	88.1%	34.8%	12.9%	17.6%
FOOD AND NUTRITION	94.3%	85.6%	32.8%	8.5%	17.6%
BIOLOGY, GENERAL AND N.E.C.	93.2%	77.3%	36.2%	14.4%	10.4%
MEDICAL SCIENCES/DEPTS MED	97.4%	69.0%	35.5%	16.4%	23.5%
INTERDISCIPLINARY, N.E.C.	89.1%	74.8%	51.2%	34.0%	16.9%
FIELD AND SETTING					
BIOLOGICAL SCIENCES, TOTAL	95.0%	85.2%	36.3%	9.1%	12.9%
GRADUATE SCHOOLS	95.2%	86.6%	33.4%	8.1%	13.1%
MEDICAL SCHOOLS	94.9%	84.3%	38.2%	9.8%	12.7%
DEPARTMENTS OF MEDICINE	96.3%	68.2%	36.9%	12.4%	19.5%
INSTITUTION CONTROL					
PRIVATE	95.9%	81.5%	31.0%	8.8%	13.6%
PUBLIC	94.9%	83.1%	39.3%	10.1%	14.1%
RESEARCH STATUS					
STATE OF THE ART	96.7%	82.2%	32.8%	12.0%	18.0%
OTHER	94.8%	82.6%	37.4%	9.0%	12.8%
PURCHASE COST					
$10,000-$24,999	95.1%	83.3%	33.1%	6.1%	12.2%
$25,000-$74,999	95.5%	81.1%	40.6%	15.8%	16.5%
$75,000-$1,000,000	95.8%	78.6%	60.9%	31.0%	25.4%

from other departments at the same institution. For microbiology, a remarkably high 50 percent of their instruments were used by researchers from other departments in the same institution. Non-academic researchers were most frequently found in molecular/cellular biology and in the medical sciences.

The second part of Table 8-7 shows that departments of medicine shared equipment most extensively with nonacademic researchers than did biological sciences. Public institutions shared with researchers from other departments at the same university a little more than did private institutions. It was somewhat more common for state-of-the-art instruments to be shared with researchers from other universities and with nonacademic researchers than it was for other instruments.

As with many other statistics examined in this report, instrument usage varied most notably by instrument purchase cost level. For graduate students and postdoctorates, there was a slight tendency for the usage proportions to decline with increasing cost of the equipment. However, a very pronounced usage increase with increasing cost of equipment was evident for researchers from other departments within the same institution, for researchers from other institutions, and for nonacademic researchers. Evidently, more expensive equipment is more likely to be shared with investigators from outside.

8.4 Summary

About 65 percent of all equipment for the biological sciences was located in the laboratories of individual investigators; for departments of medicine, 70 percent were in those locations. The remainder were in inherently shared-access facilities, the most common of which were department-managed common laboratories.

Costly instrument systems were more likely to be located in shared facilities than were those with lower purchase costs. About two-thirds of instruments costing between $75,000 and $1 million were in shared facilities, compared to about one-third of those costing from $10,000 to $24,999. Graduate schools tended to have higher proportions of their most costly instruments in shared facilities than did medical schools, as did somewhat more of the public institutions than the private institutions.

Older instruments were more likely to be located in shared facilities. Overall, 41 percent of the instruments over 10 years old were so located, compared to 32 percent of those 5 years old or less. This pattern appeared consistently in the biological science subfields, but did not appear at all in departments of medicine.

Only 17 percent of instruments in the biological sciences were dedicated to specific experiments or series of experiments, the remainder being available for general use. This proportion of dedicated equipment was about half that for most other fields of science.

The average number of users for instrument systems in the biological sciences was about 12 per instrument for general purpose instruments and about 7 for dedicated instruments. It was lower for instruments in departments of medicine. The biological sciences had fewer users per instrument than all other fields of science except agriculture. The most costly instruments in the biological sciences (those costing between $75,000 and $1 million) had substantially more users per instrument than those in lower cost categories.

The more costly instrument systems (over $75,000) were very likely to have been used by investigators from outside the department, and even from outside the institution. There was also a tendency for state-of-the-art instruments to be used by a wider range of users than equipment not considered state-of-the-art.

In the biological sciences, considerable sharing routinely takes place, especially with instruments not dedicated to specific experiments. The percentages of instruments used by researchers from within the same department, by graduate and medical students and postdoctorates, and by members of other departments in the same institution -- all indicate an impressive amount of cross-usage of instruments. Additionally, a high percentage of instruments are located in inherently shared-access facilities, and there is especially widespread use of the most expensive instruments. Thus, one can conclude that in academic sciences sharing of equipment is the rule and not the exception.

9. MAINTENANCE AND REPAIR

The effective cost of research instrumentation extends beyond original acquisition cost. The quality of an instrument's performance and its longevity depend on adequate maintenance practices throughout its working life. A number of questions relating to the quality and costs of maintenance and repair (M&R) were asked in the survey of both department heads and users of instruments. This chapter presents the findings on M&R for the biological and medical sciences.

9.1. Assessment of M&R Facilities

Department/facility heads assessed the instrumentation support services available to their departments, including such facilities as electronics and machine shops. Their evaluations are reported in Table 9-1.

Overall, only 16 percent regarded their facilities as excellent, and nearly 50 percent reported insufficient or non-existent facilities. The patterns of response among the departments were quite varied. Departments of molecular/cellular biology and physiology/biophysics assessed 32 percent of their M&R facilities as excellent. Departments of food/nutrition, however, could find no facilities to rate as excellent, while for botany and pathology there were only 6 percent and 8 percent respectively, of excellent facilities. Thirty-eight percent of the pharmacology/ toxicology departments reported that they had no M&R facilities at all.

TABLE 9-1
DEPARTMENT/FACILITY ASSESSMENT OF AVAILABLE INSTRUMENTATION SUPPORT SERVICES
BIOLOGICAL AND MEDICAL SCIENCES

	PERCENT OF DEPARTMENTS/FACILITIES ASSESSING INSTRUMENTATION SUPPORT SERVICES AS:				
	TOTAL	EXCELLENT	ADEQUATE	INSUFFICIENT	NONEXISTENT
TOTAL	100	16	36	31	17
DEPARTMENTS					
BIOCHEMISTRY	100	16	30	37	17
MICROBIOLOGY	100	12	37	33	18
MOLECULAR/CELLULAR BIOLOGY	100	32	35	9	24
PHYSIOLOGY/BIOPHYSICS	100	32	38	17	13
ANATOMY	100	22	46	22	10
PATHOLOGY	100	8	26	44	22
PHARMACOLOGY/TOXICOLOGY	100	20	18	24	38
ZOOLOGY/ENTOMOLOGY	100	12	31	39	18
BOTANY	100	6	54	18	22
FOOD AND NUTRITION	100	0	33	53	14
BIOLOGY, GENERAL AND N.E.C.	100	13	33	38	16
DEPARTMENTS OF MEDICINE	100	6	64	30	0
FIELD AND SETTING					
BIOLOGICAL SCIENCES, TOTAL	100	16	34	31	18
GRADUATE SCHOOLS	100	16	34	33	17
MEDICAL SCHOOLS	100	17	34	29	20
DEPARTMENTS OF MEDICINE	100	6	64	30	0
INSTITUTION CONTROL					
PRIVATE	100	30	29	19	22
PUBLIC	100	9	39	36	16

Only 6 percent of the departments of medicine viewed their M&R facilities as excellent, but 64 percent stated that they were adequate, for a total of 70 percent rated adequate or better. All departments of medicine reported that they had some kind of M&R facility. The biological sciences as a whole had a less satisfactory view of their M&R facilities, with a total of 50 percent having adequate or better facilities and 18 percent reporting none at all.

Private institutions rated 30 percent of their facilities as excellent, a much larger proportion than the 9 percent for public institutions. Private institutions also reported a higher proportion of departments without M&R facilities -- 22 percent to 16 percent.

9.2 The Costs of M&R

It has already been shown (Table 4-1) that $35.7 million was spent for M&R in FY 1983 by academic departments and facilities in the biological and medical sciences, compared to $158.2 million in reported purchases by the same departments and facilities for items of research equipment costing $500 or more. This amounted to 22.5 cents spent on M&R for every dollar spent to acquire new equipment in that year.

There are several facets of expenditures for M&R. They may be described as: (1) costs of services provided by sources outside the institution -- i.e., service contracts and field service as needed; (2) salaries for university-employed M&R personnel; and (3) costs of supplies, equipment, and facilities used for M&R within the department.

The mean expenditure per department for all these costs was $30,200 in FY 1983, of which nearly two-thirds was spent for outside services, as shown in Table 9-2. There was considerable variation by department in mean expenditure. Among the biological sciences, the largest mean expenditures were found for general biology ($36,200), physiology/biophysics ($35,900), and molecular/ cellular biology ($35,700). The smallest mean expenditures were made by food/nutrition ($15,100), botany ($16,900), and microbiology ($17,300).

The biological science departments also varied in their relative use of outside services as opposed to university-based M&R staff and facilities. While the overall proportion spent by biological science departments for outside services was 62 percent of M&R funds, departments of zoology/entomology used only 38 percent of their funds for outside services, with the remainder going into university staff salaries and the supplies and facilities used by those staff members. Similarly, for physiology/biophysics 47 percent went into outside services. At the other end were botany (80 percent for outside services), pharmacology/toxicology (77 percent), and microbiology (73 percent).

M&R expenditures for departments of medicine were quite different from those for the biological sciences, averaging $59,700 per department, compared to $25,800 for graduate schools and $31,300 for biological sciences in medical schools. Moreover, departments of medicine relied on outside services more heavily, spending 76 percent of their M&R funds for this purpose compared to 62 percent for the biological sciences. The larger mean expenditure for departments of medicine can be traced to their greater size; there were more than twice as many instruments in use per department for departments of medicine as there were for the average biological sciences department. The differential in mean expenditures disappears when this factor is controlled.

TABLE 9-8
MEAN FY 1983 EXPENDITURE PER DEPARTMENT/FACILITY FOR MAINTENANCE AND REPAIR OF RESEARCH EQUIPMENT:
BIOLOGICAL AND MEDICAL SCIENCES

(DOLLARS IN THOUSANDS)

	PER DEPARTMENT MEAN FY 1983 EXPENDITURE FOR MAINTENANCE AND REPAIR OF RESEARCH EQUIPMENT			
	TOTAL	M/R SERVICE CONTRACTS AND FIELD SERVICE	UNIVERSITY-EMPLOYED M/R PERSONNEL SALARIES	M/R SUPPLIES EQUIPMENT AND FACILITIES
TOTAL, SELECTED FIELDS	$30.2	$19.0	$6.4	$4.8
DEPARTMENTS				
BIOCHEMISTRY	29.7	19.6	6.0	4.0
MICROBIOLOGY	17.3	12.7	1.9	2.7
MOLECULAR/CELLULAR BIOLOGY	35.7	22.7	8.0	5.0
PHYSIOLOGY/BIOPHYSICS	33.9	16.7	12.8	6.4
ANATOMY	30.5	18.5	4.1	7.9
PATHOLOGY	28.9	19.4	6.2	3.2
PHARMACOLOGY/TOXICOLOGY	27.5	21.1	2.6	3.7
ZOOLOGY/ENTOMOLOGY	21.3	8.1	7.5	5.7
BOTANY	16.9	13.6	1.9	1.3
FOOD AND NUTRITION	15.1	8.7	3.7	2.7
BIOLOGY, GENERAL AND N.E.C.	36.2	21.2	9.5	5.5
DEPARTMENTS OF MEDICINE	59.7	45.4	6.7	7.6
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	28.6	17.6	6.4	4.6
GRADUATE SCHOOLS	25.8	16.1	5.7	4.1
MEDICAL SCHOOLS	31.3	19.0	7.1	5.2
DEPARTMENTS OF MEDICINE	59.7	45.4	6.7	7.6
INSTITUTION CONTROL				
PRIVATE	39.6	26.5	7.3	5.8
PUBLIC	26.0	15.6	6.0	4.3

Private institutions spent 50 percent more per department on M&R than public institutions. Sixty-seven percent of their M&R expenditures went into outside services, compared to 60 percent for public institutions.

The methods of providing M&R service are presented in more detail in Table 9-3. These data, and those for the remaining tables in this chapter, were supplied by instrument users on the Instrument Data Sheet. As shown in Table 9-3, 39 percent of the instrument systems were maintained under service contract. Field service as needed was employed for 27 percent of the instruments, university-based M&R staff serviced 10 percent, and research personnel handled 8 percent. Overall, 17 percent of the systems did not have service contracts and did not require any servicing during the year.

About 50 percent of the instruments used in microbiology and molecular/cellular biology were under service contract, whereas only 9 percent of those in food/nutrition, 18 percent of those in zoology/entomology, and 23 percent of those in physiology/biophysics had service contracts. Food/nutrition tended to use local M&R staff and research personnel instead of service contracts to perform the necessary service, and zoology/entomology often used field service. In both these subfields, about 30 percent of their instruments required no service at all. Physiology/biophysics also used university staff and research persons more frequently than other subfields instead of service contracts.

There were essentially no differences between departments of medicine and the biological sciences in patterns of M&R servicing. Private institutions, however, tended to use service contracts and field services about 20 percent more often than public institutions.

TABLE 9-3
PRINCIPAL MEANS OF SERVICING IN-USE ACADEMIC RESEARCH INSTRUMENTS: BIOLOGICAL AND MEDICAL SCIENCES [1]

	PERCENT OF IN-USE SYSTEMS BY PRINCIPAL MEANS OF SERVICING [2]					
	TOTAL	SERVICE CONTRACT	NONE REQUIRED	FIELD SERVICE	UNIV. M/R PERSONNEL	RESEARCH PERSONNEL
TOTAL, SELECTED FIELDS	100%	39%	17%	27%	10%	8%
SUBFIELD OF RESEARCH						
BIOCHEMISTRY	100	42	14	26	9	8
MICROBIOLOGY	100	52	17	20	6	6
MOLECULAR/CELLULAR BIOLOGY	100	51	13	28	4	5
PHYSIOLOGY/BIOPHYSICS	100	23	22	27	16	12
ANATOMY	100	36	33	25	1	5
PATHOLOGY	100	44	13	31	7	6
PHARMACOLOGY/TOXICOLOGY	100	38	17	24	8	13
ZOOLOGY/ENTOMOLOGY	100	18	31	37	8	6
BOTANY	100	32	14	30	17	7
FOOD AND NUTRITION	100	9	30	29	22	11
BIOLOGY, GENERAL AND N.E.C.	100	35	19	23	16	8
MEDICAL SCIENCES/DEPTS. MED	100	38	15	31	13	.4
INTERDISCIPLINARY, N.E.C.	100	27	16	19	11	28
FIELD AND SETTING						
BIOLOGICAL SCIENCES, TOTAL	100	39	17	26	10	9
GRADUATE SCHOOLS	100	38	16	26	11	8
MEDICAL SCHOOLS	100	40	18	26	8	9
DEPARTMENTS OF MEDICINE	100	38	15	31	11	5
INSTITUTION CONTROL						
PRIVATE	100	44	19	23	9	5
PUBLIC	100	36	16	28	10	10

[1] PERCENTS MAY NOT SUM TO 100 BECAUSE OF ROUNDING.

[2] IF MORE THAN ONE FORM OF SERVICING WAS USED IN 1983, THE INSTRUMENT SYSTEM WAS ASSIGNED TO THE FIRST-LISTED CATEGORY THAT APPLIED.

9.3 Relationship of Means of Servicing to Working Condition

In Table 9-4, an analysis is presented of the proportion of instruments in excellent working condition by the means used to service the instrument in 1983, with age of equipment held constant. It has already been shown (Figure 6-3) that a strong relationship exists between the age of an instrument and its working condition; this relationship is also reflected in Table 9-4. Within each age category, however, there seems to be little difference in proportion of instruments in excellent condition between those under service contract and those receiving M&R by any other means. (The category No Service Required, of course, is excluded in this analysis.)

This lack of relationship between 1983 means of servicing and 1983 working condition, while interesting, does not necessarily imply a wider lack of relationship between an instrument's history of M&R and its mechanical longevity. Longitudinal data would be required for the examination of such cause-and-effect relationships.

9.4 M&R Costs and Age of Instruments

M&R for an instrument system in the biological and medical sciences costs more after the instrument is over five years old, according to Table 9-5. Overall, the mean expenditure per system for M&R in FY 1983 was $900 for systems from 1 to 5 years old, $1,400 for those between 6 and 10 years old, and $1,300 for those 11 years and older. The pattern of lower M&R costs during the first five years held true for all subfields.

TABLE 9-4
PERCENT OF IN-USE ACADEMIC RESEARCH INSTRUMENT SYSTEMS THAT ARE IN EXCELLENT WORKING CONDITION, BY SYSTEM AGE: BIOLOGICAL AND MEDICAL SCIENCES

	PERCENT OF IN-USE SYSTEMS IN EXCELLENT WORKING CONDITION, [1] BY SYSTEM AGE			
	TOTAL	1-5 YEARS (1979-83)	6-10 YEARS (1974-78)	11+ YEARS (BEFORE 1974)
TOTAL, SELECTED FIELDS	53%	71%	41%	26%
PRINCIPAL MEANS OF SERVICING [2]				
SERVICE CONTRACT	49	66	40	28
NO SERVICE REQUIRED	76	88	64	40
FIELD SERVICE, AS NEEDED	51	71	39	24
UNIVERSITY-EMPLOYED MAINTENANCE/REPAIR STAFF	39	56	29	22
RESEARCH PERSONNEL (FACULTY, POST-DOCS, GRADUATE STUDENTS)	44	65	42	20

[1] BASED ON USER CHARACTERIZATION.

[2] IF MORE THAN ONE FORM OF SERVICING WAS USED IN 1983, THE INSTRUMENT SYSTEM WAS ASSIGNED TO THE FIRST-LISTED CATEGORY THAT APPLIED.

TABLE 9-5
MEAN EXPENDITURE IN 1983 PER SYSTEM FOR MAINTENANCE AND REPAIR OF IN-USE ACADEMIC RESEARCH INSTRUMENT SYSTEMS, BY SYSTEM AGE: BIOLOGICAL AND MEDICAL SCIENCES

	PER SYSTEM MEAN EXPENDITURE IN 1983 FOR MAINTENANCE AND REPAIR, BY SYSTEM AGE			
	TOTAL	1-5 YEARS (1979-83)	6-10 YEARS (1974-78)	11+ YEARS (BEFORE 1974)
TOTAL, SELECTED FIELDS	$1,100	$900	$1,400	$1,300
SUBFIELD OF RESEARCH				
BIOCHEMISTRY	1,000	800	1,300	1,100
MICROBIOLOGY	1,200	900	1,100	1,800
MOLECULAR/CELLULAR BIOLOGY	1,200	800	1,600	1,400
PHYSIOLOGY/BIOPHYSICS	900	800	1,000	900
ANATOMY	1,600	800	2,200	2,400
PATHOLOGY	1,600	1,000	1,600	2,400
PHARMACOLOGY/TOXICOLOGY	1,100	1,100	1,300	700
ZOOLOGY/ENTOMOLOGY	700	300	1,500	1,400
BOTANY	800	800	1,100	800
FOOD AND NUTRITION	600	500	500	1,000
BIOLOGY, GENERAL AND N.E.C.	1,700	1,300	1,300	2,400
MEDICAL SCIENCES/DEPTS. MED	1,400	1,200	2,000	1,000
INTERDISCIPLINARY, N.E.C.	2,000	1,400	1,900	3,800
FIELD AND SETTING				
BIOLOGICAL SCIENCES, TOTAL	1,100	800	1,300	1,400
GRADUATE SCHOOLS	1,000	700	1,300	1,200
MEDICAL SCHOOLS	1,200	900	1,300	1,500
DEPARTMENTS OF MEDICINE	1,200	1,100	1,600	1,000
INSTITUTION CONTROL				
PRIVATE	1,300	900	1,500	1,500
PUBLIC	1,100	800	1,300	1,300
SYSTEM PURCHASE COST				
$10,000-$24,999	700	500	900	700
$25,000-$74,999	1,400	800	1,900	2,400
$75,000-$1,000,000	6,300	5,900	6,200	6,500
PRINCIPAL MEANS OF SERVICING [1]				
SERVICE CONTRACT	2,300	2,000	2,300	2,500
NO SERVICE REQUIRED	0	0	0	0
FIELD SERVICE, AS NEEDED	700	500	800	1,000
UNIVERSITY-EMPLOYED MAINTENANCE/REPAIR STAFF	600	500	500	800
RESEARCH PERSONNEL (FACULTY, POST-DOCS, GRADUATE STUDENTS)	400	300	300	500

[1] IF MORE THAN ONE FORM OF SERVICING WAS USED IN 1983, THE INSTRUMENT SYSTEM WAS ASSIGNED TO THE FIRST-LISTED CATEGORY THAT APPLIED.

The mean expenditure for all instruments was $1,100. The subfields with the lowest M&R expenditures were food/nutrition ($600), zoology/entomology ($700), botany ($800), and physiology/biophysics ($900). The highest expenditures were made by general biology ($1,700) and pathology and anatomy ($1,600 each).

Departments of medicine and biological sciences had nearly the same mean expenditures. Private institutions spent $1,300 per instrument on M&R, while public institutions spent $1,100.

Large differences in mean M&R expenditures were found for size of instrument purchase cost. For instrument systems costing between $10,000 and $24,999, an average of $700 was spent for M&R. The mean expenditure for those costing between $25,000 and $74,999 was $1,400, and for the most costly instruments, the mean expenditure was $6,300. This M&R cost differential was reflected in each of the age categories, especially for those 11 years and older.

Service contracts were by far the most costly means of performing M&R service with an average of $2,300 per instrument, compared to $700 for field service, $600 for M&R staff within the university, and $400 for research personnel. The costs for all means of servicing increased with age of instrument, the increment in cost for instruments 5 years old or less and that for instruments 11 years and older being 25 percent for service contracts, 100 percent for field service, 60 percent for M&R staff, and 67 percent for research personnel.

9.5 Summary

Only 16 percent of departments in the biological and medical sciences considered their facilities for maintenance and repair as excellent, while nearly 50 percent reported insufficient or nonexistent facilities. Departments of medicine were more satisfied with their M&R facilities than were departments in the biological sciences. All departments of medicine had such facilities, while 18 percent of biological science departments did not.

In FY 1983, 22.5 cents were spent on M&R for every dollar spent for new equipment. The mean expenditure per department for M&R was $30,200. Nearly two thirds of this amount went into service contracts and field service as needed. Private institutions spent 50 percent more per department than public institutions.

Instruments were serviced under contract more frequently than by any other means, followed by field service. No servicing was required for 17 percent of the instruments. Negligible differences were found in the proportions of instruments in excellent working condition between instruments under service contract and those maintained by other means, when age of instruments was held constant.

The amount spent per instrument for M&R rose after the instrument became six years old. While the overall mean expenditure per instrument was $1,100, it was $900 for those between 1 and 5 years old, and over $1,300 for those over 5 years of age. The mean M&R expenditure for instruments costing from $75,000 to $1 million, $6,300, was far more than the $700 expended for those costing between $10,000 and $29,999. Service contracts cost an average of $2,300 per instrument, compared to $700 for field service and less for other means of servicing.

In comparisons among the biological science disciplines, those with the most favorable (and satisfactory) M&R resources were consistently molecular/cellular biology and physiology/biophysics, followed by general biology. The least satisfactory was food/nutrition.

10. SUMMARY

10.1 Overview

The results of this study indicate that there are deficiencies in the current levels of instrumentation. The extent of the deficiencies varies significantly among the subfields of research. More advanced instrumentation is needed to allow investigators to perform critical experiments which cannot now be adequately conducted. Better maintenance and repair facilities are needed. Although 18 percent of the current national stock of equipment is considered state-of-the-art, that status is lost very rapidly; the need for upgrading is continuous and of the highest importance.

10.2 Department-Level Findings

More than half of the heads of departments/facilities, in assessing the needs and priorities of their departments, stated that critical scientific experiments could not be conducted because their departments lacked appropriate instrumentation. This was more often stated for the biological sciences than for departments of medicine, and for public institutions than for private institutions.

The capability of existing research equipment to enable researchers to pursue their major research interests was rated excellent for tenured faculty by only one-sixth of the departments, while more than one-fourth rated their capability as insufficient. The proportion rated insufficient for untenured faculty was one-third. More than twice as many graduate school departments as departments in medical schools answered "insufficient," however, and three times as many departments in public institutions as in private institutions did so. Compared with other fields of science, the biological sciences as a whole had a more favorable assessment of their current stock of equipment than any other field, but this was primarily due to medical schools. For biological science departments in graduate schools, the degree of insufficiency matched that given by graduate school departments in other fields, such as physical sciences and engineering.

Although these assessments are based not on quantitative data but rather on informed opinion, the consistency with which some large groups report more inadequacies than other groups indicates a widespread perception of a problem.

If increased Federal funding were available for purchase of research equipment, two-thirds of heads of departments/facilities would put funds into instruments costing between $10,000 and $50,000, while another 20 percent desired instruments costing between $50,000 and $1 million. Private institutions preferred more instruments in the upper range than public institutions. In other fields of science, there was more of a need for $50,000 to $1 million instruments than was found in the biological sciences, and even for systems costing above $1 million -- which none of the department heads in the biological sciences mentioned as a top priority need.

When asked to list the three research instruments costing between $10,000 and $1 million that were most urgently needed, department heads often listed various types of preparative instruments. For most disciplines, these were the most frequently needed items. Nearly 80 percent of the instruments mentioned were in categories where the median cost of the instrument was under $75,000. Instruments with a median cost over $100,000 that were mentioned most frequently were electron microscopes and NMRs.

A total of $158 million was spent on research equipment costing over $500 in FY 1983 by the biological sciences and departments of medicine, with an additional $36 million spent on maintenance and repair of research equipment. The mean amount spent for research equipment in FY 1983 was $48,000 per annual doctoral degree awarded. The mean amount per faculty-level researcher was $5,900. Medical schools spent about twice the amount per doctoral degree and researcher as graduate schools, and private institutions considerably more than public institutions.

10.3 The National Stock of Academic Research Equipment

There were over 21,000 instrument systems in the current inventories of the biological sciences and departments of medicine, with an aggregate purchase cost of $555 million. In terms of constant 1982 dollars, the cost of these instruments is estimated at $863 million. The biological sciences had more instrument systems than any other field of academic science, but the mean cost per instrument system ($27,000) was the lowest for any field except agricultural sciences.

About three-fourths of all presently existing academic research instruments in the biological and medical sciences cost between $10,000 and $25,000. Only 5 percent cost between $75,000 and $1 million, but they accounted for one-fourth of all funds spent for equipment. Mean dollar amount of research instrumentation per researcher in the biological sciences was about $21,000, but the amount in medical schools per researcher was 50 percent higher than in nonmedical schools. For departments of medicine, the mean equipment investment per researcher was $15,000. Mean aggregate equipment cost per doctoral degree awarded in 1982-83 in the biological sciences was $143,500, but for medical schools that cost was more than twice as much as for nonmedical schools.

Private institutions had higher investments per researcher and per graduate degree than public institutions.

State-of-the-art instruments constituted 18 percent of the national stock in 1983, although the percentage was larger in private institutions than public institutions. Another 65 percent were in active research use, although not classified as state-of-the-art. Instruments that were not in active use because of technological obsolescence or inoperable mechanical condition, but that were still physically present at the institution, constituted another 16 percent of the national stock. Departments of medicine, however, had twice as large a percentage of obsolete or inoperable instruments on their inventories as the biological sciences.

10.4 Age and Condition of Academic Research Equipment

For all instruments in the national stock, 44 percent were from one to five years old, and 27 percent were over 10 years old. Omitting the inactive systems from consideration, the proportion of instruments aged 1 to 5 years was 50 percent, and 22 percent were over 10 years old. For instrument systems that were in active research use, departments of medicine had a higher proportion of newer instruments than did the biological sciences, and private institutions had a higher proportion than public institutions. Instruments in the biological sciences were somewhat older than those in other fields of science.

Most of the state-of-the-art instruments in 1983 were relatively new. Fifty percent of instruments purchased in 1983 were state-of-the-art, but of those purchased two years earlier (in 1981), only 37 percent were still considered state-of-the-art. Six-year-old instruments were classified as state-of-the-art only 13 percent of the time. Altogether, 85 percent of the state-of-the-art instruments were from 1 to 5 years old, and only 3 percent were over 10 years old.

About half of all instrument systems actively in use for research were in excellent working condition. As would be expected, there is a relationship between working condition and age of the instrument. Thus 78 percent of instruments from 1 to 3 years old were in excellent condition; of the instruments 4 to 6 years old, 57 percent were in excellent condition; and of those 10 to 12 years old, only 26 percent were rated as excellent. Accompanying this decline in operating condition with age of instrument was the "retirement" of instruments as they got older. In the biological sciences, 60 percent of instruments that were inactive (presumably because of mechanical or technological obsolescence) were over 10 years old.

Of the state-of-the-art systems, which were relatively new, 85 percent were considered to be in excellent condition. Only 44 percent of those not considered state-of-the-art were in excellent condition, however. These "other" systems were considerably older and they constituted nearly 80 percent of all equipment in active use.

A substantial amount of other than state-of-the-art equipment is to be expected. Much of laboratory research does not require the most advanced instrumentation. A problem arises, however, when investigators using non-state-of-the-art equipment do not have access to more advanced equipment when needed. This problem was found frequently; nearly half of the non-state-of-the-art instruments in research use were the most advanced instruments of their kind to which users had access. This situation is an obstacle for investigators attempting to engage in more sophisticated research. The entire research effort in the biological sciences is hindered when problems such as mechanically unreliable equipment and lack of access to advanced instrumentation become prevalent.

10.5 Funding of Equipment in Active Research Use

Almost all research instruments (94%) in the biological sciences and departments of medicine were acquired new. Sources of funding were evenly split between Federal and non-Federal sources for the biological sciences, but for departments of medicine, nearly two-thirds of the funds came from non-Federal sources. For private institutions, a larger proportion of equipment funds came from Federal sources than was the case for public institutions.

NIH was the principal source of Federal funds for acquisition of research equipment in the biological and medical sciences, contributing 44 percent of all funds for medical schools and 31 percent for graduate schools. NSF was the only other major Federal source, contributing more to graduate schools than to medical schools. The institutions were the major source of non-Federal funds. State governments and private foundations gave only small amounts for research equipment. The amount contributed by business and industry for equipment was negligible.

NIH funds, while accounting for 38 percent of all equipment purchases, contributed 47 percent of the support for purchases of instruments in the $10,000 to $25,000 range, but only 28 percent of the dollar support for existing equipment costing $75,000 or more. Institutions, however, which contributed 37 percent of all funds for equipment, purchased 31 percent of the instruments costing under $25,000 and 41 percent of those costing $75,000 or more. NSF-supported purchases for equipment followed the same pattern as that for institutions.

Sixty percent of all biological science instruments received full or partial Federal funding, compared to 48 percent of those in departments of medicine.

10.6 Location and Use of Academic Research Equipment

About 65 percent of all equipment in the biological sciences and 70 percent in departments of medicine was located in the laboratories of individual investigators. The remainder was in inherently shared-access facilities, mostly department-managed common laboratories. Costly instruments were frequently located in the inherently shared-access facilities; this held true to a greater extent for graduate schools than for medical schools, and for public institutions than for private institutions. Older instruments were also more likely to be located in inherently shared-access facilities.

Location of instruments within laboratories of individual investigators did not necessarily mean that they were not shared. The mean number of users of all instruments was 11 per instrument. The large majority of instrument systems were available for general purposes, as opposed to being dedicated for specific experiments. For these general purpose instruments, the mean number of users was almost 12 per instrument.

About 95 percent of all instruments in the biological sciences were used by faculty within the same department, and 85 percent were also used by graduate students, medical students, and postdoctorates from the departments. Additionally, 36 percent were used by faculty from other departments in the institution. Researchers from other universities and nonacademic researchers used the more costly instruments far more frequently than the lower-cost ones; this held true also for researchers from other departments at the same institution.

The average instrument in an investigator's laboratory is freely accessible to other research investigators, as evidenced by the numbers of users and the origins of users. From this conclusion, together with the 35 percent of all instruments located in facilities that are -- by their very nature -- shared-access, it is evident that sharing of research equipment is common in academic facilities.

10.7 Maintenance and Repair

Nearly 50 percent of department/facilities heads assessed their maintenance and repair (M&R) facilities as either insufficient or nonexistent. Overall, only 16 percent regarded their facilities as excellent. In private institutions, however, 30 percent rated their facilities as excellent, compared to 9 percent for public institutions.

M&R expenditures in FY 1983 were $35.7 million, which amounted to 22.5 cents spent for M&R in that year for every dollar spent to acquire new equipment.

The mean expenditure per department for M&R in FY 1983 was $30,200. Nearly two-thirds of that expenditure was used for outside services, i.e., service contracts or field services as needed.

For instruments in research use during 1983 the mean M&R expenditure was $1,100. Instruments that were from 1 to 5 years old, however, had a mean M&R expenditure of $900, compared to over $1,300 for those more than 5 years old. The original purchase cost of instruments gave rise to the largest differences in mean M&R expenditures: for those costing under $25,000 the mean M&R outlay was $700 in 1983; for those costing between

$25,000 and $74,999 it was $1,400; and for those costing between $75,000 and $1 million the mean 1983 expenditure for M&R was $6,300.

Service contracts cost an average of $2,300 per instrument, compared to $700 for field service and less for other means of servicing. They were used to maintain 39 percent of the instruments. An additional 27 percent of the instruments were given field service as needed. Research personnel and university-based M&R staff performed this service for 18 percent of the instruments. The remaining 17 percent neither had service contracts nor required M&R in 1983.

10.8 Group Comparisons

Thus far, findings have been summarized with respect to topic areas. In addition, numerous differences were observed among groups of institutions, among subfields of research within the biological and medical sciences, and between the biological sciences and the other fields of science encompassed in the larger two-year study of academic research equipment. These group comparisons are briefly summarized here.

10.8.1 Differences Among Institutions

(1) Medical and graduate (nonmedical) schools. Levels of investment in research instrumentation were substantially higher for medical schools than for other academic institutions. For all indices examined -- equipment per institution, per instrument, per faculty-level researcher, per doctoral degree awarded -- medical schools had larger instrumentation investments, both aggregate and current, than graduate (nonmedical) schools.

(2) Private and public institutions. Privately controlled institutions consistently showed an advantage over public institutions on a number of important dimensions. Their research instruments generally cost more, were newer, and were better able to meet research needs. Private institutions also had better maintenance facilities.

10.8.2 Differences Among Subfields of Research in the Biological Sciences

Certain subfields of research stand out from the others in some characteristics. A brief summary of major differences follows.

- Biochemistry had the largest number of instruments costing over $10,000 -- nearly 4,500. It also had a higher proportion of instruments funded by Federal agencies than any other subfield.

- In many respects, molecular/cellular biology appeared to be the best equipped research subfield. It had the second largest number of instruments, 2,900. In percentage of instruments in excellent working condition, it ranked very high. Department heads in this discipline were more satisfied with the quality of their current instrumentation than in any other subfield. Equipment expenditures per faculty researcher in 1983 exceeded by a large amount those for all other disciplines.

- Anatomy and pathology were two of the smaller subfields in numbers of instruments. They had the highest costs per instrument, $32,000 and $31,000 respectively. Both subfields, particularly anatomy, also had unusually high proportions of instruments over 10 years old in active research use.

- Zoology, botany, and food/nutrition were disciplines found almost entirely in nonmedical subdivisions of universities. They were the three subfields with the smallest numbers of instruments. Very high proportions of department heads stated that critical experiments could not be performed in these disciplines because they lacked appropriate instrumentation. Food/nutrition had the lowest cost per instrument ($22,000) of any subfield, the poorest maintenance, and had, by far, the lowest percentage of Federal funding for its equipment.

10.8.3 Differences Between Departments of Medicine and Biological Science Fields

Departments of medicine, included in the survey as an experiment to assess the feasibility of obtaining instrumentation indicators for medical (clinical) sciences, apparently can provide data on samples of research instruments as easily as the biological sciences. With respect to Department/Facility Questionnaires, however, it was learned that some of the larger, more diverse departments of medicine had difficulty in assembling expenditure, funding, and needs data for all the clinical fields subsumed within their jurisdictions. A better approach to collecting such data might be to go directly to each of the component clinical programs or subunits of departments of medicine.

For most of the analyses performed in this report, departments of medicine (and presumably, the clinical sciences) had somewhat different results than the biological sciences. Departments of medicine apparently retired instruments at an earlier age than did the biological sciences. Within medical schools, the average costs of equipment per researcher were nearly twice as large for the biological sciences as for departments of medicine. This difference on an index of equipment intensity is probably a function of the kinds of research performed by physician-researchers in clinical departments, compared with those in the basic biological sciences. Whereas over half of the funds for purchase of equipment in the biological sciences came from Federal agencies, 38 percent of equipment funds came from those sources for departments of medicine. The difference was made up by institutional funds, indicating a possible difference in institutional resources between the clinical and biological sciences. Departments of medicine also had better maintenance and repair facilities than the biological sciences.

10.8.4 Differences Between Biological Sciences and Other Fields of Science

The biological sciences differed from the other fields of science addressed in the survey. They accounted for 38 percent of the instruments in all the fields surveyed; the next largest field was the physical sciences, with 25 percent of all instruments. The mean cost per instrument in the biological sciences was $27,000, compared to $41,000 for the physical sciences and $35,000 for engineering. Instruments in the biological sciences were somewhat older than those in other fields, but fewer instruments in the national stock in biology were technologically or mechanically obsolete. The average instrument in the biological sciences was used by somewhat fewer investigators than was the case in other fields. The funding pattern for the biological sciences was unlike that for any other field, because of the prominence of NIH as a funding source in the biological sciences: NIH directly contributed 39 percent of the costs of all academic instrumentation in this field.

APPENDIX A

COMPARISON TABLES FOR ALL FIELDS OF SCIENCE

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TABLE A-1

NUMBER OF DEPARTMENTS AND FACILITIES AND PERCENT REPORTING IMPORTANT SUBJECT AREAS IN WHICH CRITICAL EXPERIMENTS CANNOT BE PERFORMED DUE TO LACK OF NEEDED EQUIPMENT BY FIELD [1]

	NUMBER OF DEPARTMENTS/FACILITIES	PERCENT REPORTING INABILITY TO CONDUCT CRITICAL EXPERIMENTS DUE TO LACK OF NEEDED EQUIPMENT
TOTAL, SELECTED FIELDS	2807	74
FIELD OF RESEARCH		
AGRICULTURAL SCIENCES	241	83
BIOLOGICAL SCIENCES, TOTAL	1138	59
GRADUATE SCHOOLS	550	60
MEDICAL SCHOOLS	588	58
ENVIRONMENTAL SCIENCES	235	63
PHYSICAL SCIENCES	367	89
ENGINEERING	652	90
COMPUTER SCIENCE	89	93
MATERIALS SCIENCE	19	100
INTERDISCIPLINARY, N.E.C.	65	76

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 897 DEPARTMENTS AND FACILITIES.

TABLE A-2
DEPARTMENT/FACILITY ASSESSMENT OF ADEQUACY OF AVAILABLE RESEARCH INSTRUMENTATION, BY FIELD [1]

	PERCENT OF DEPARTMENTS/FACILITIES ASSESSING INSTRUMENTATION AVAILABLE TO TENURED FACULTY AND EQUIVALENT P.I.'s AS:				PERCENT OF DEPARTMENTS/FACILITIES ASSESSING INSTRUMENTATION AVAILABLE TO UNTENURED FACULTY AND EQUIVALENT P.I.'s AS:			
	TOTAL	EXCELLENT	ADEQUATE	INSUFFICIENT	TOTAL	EXCELLENT	ADEQUATE	INSUFFICIENT
TOTAL, SELECTED FIELDS	100%	11%	53%	36%	100%	10%	47%	43%
FIELD OF RESEARCH								
AGRICULTURAL SCIENCES	100%	8%	47%	44%	100%	8%	39%	52%
BIOLOGICAL SCIENCES, TOTAL	100%	15%	59%	26%	100%	15%	53%	32%
GRADUATE SCHOOLS	100%	14%	48%	39%	100%	15%	42%	43%
MEDICAL SCHOOLS	100%	16%	69%	15%	100%	15%	63%	22%
ENVIRONMENTAL SCIENCES	100%	10%	66%	25%	100%	10%	54%	36%
PHYSICAL SCIENCES	100%	4%	54%	42%	100%	2%	49%	49%
ENGINEERING	100%	9%	42%	50%	100%	6%	37%	57%
COMPUTER SCIENCE	100%	2%	52%	45%	100%	2%	52%	46%
MATERIALS SCIENCE	100%	27%	58%	15%	100%	20%	35%	45%
INTERDISCIPLINARY, N.E.C.	100%	30%	33%	37%	100%	32%	30%	37%

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 897 DEPARTMENTS AND FACILITIES.

TABLE A-3
DEPARTMENT/FACILITY RECOMMENDATIONS FOR INCREASED FEDERAL SUPPORT FOR RESEARCH INSTRUMENTATION, BY FIELD [1]

	PERCENT OF DEPARTMENTS/FACILITIES RECOMMENDING AS TOP PRIORITY AREA FOR INCREASED FEDERAL SUPPORT OF ACADEMIC RESEARCH EQUIPMENT:					
	TOTAL	LARGE SCALE FACILITIES	SYSTEMS IN $50,000-$1,000,000 RANGE	SYSTEMS IN $10,000-$50,000 RANGE	LAB EQUIPMENT UNDER $10,000	OTHER
TOTAL, SELECTED FIELDS	100%	2%	26%	61%	10%	1%
FIELD OF RESEARCH						
AGRICULTURAL SCIENCES	100%	-	6%	79%	15%	-
BIOLOGICAL SCIENCES, TOTAL	100%	-	20%	66%	13%	2%
GRADUATE SCHOOLS	100%	-	21%	63%	15%	1%
MEDICAL SCHOOLS	100%	-	19%	69%	10%	2%
ENVIRONMENTAL SCIENCES	100%	6%	36%	54%	2%	2%
PHYSICAL SCIENCES	100%	5%	43%	44%	6%	2%
ENGINEERING	100%	3%	28%	60%	9%	-
COMPUTER SCIENCE	100%	-	25%	75%	-	-
MATERIALS SCIENCE	100%	-	83%	17%	-	-
INTERDISCIPLINARY, N.E.C.	100%	-	48%	45%	7%	-

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 897 DEPARTMENTS AND FACILITIES.

TABLE A-4
TOTAL AMOUNT AND COST OF ACADEMIC RESEARCH INSTRUMENTATION IN NATIONAL STOCK, BY FIELD [1]

[DOLLARS IN THOUSANDS]

	NUMBER AND PERCENT OF INSTRUMENT SYSTEMS	AGGREGATE PURCHASE COST AND PERCENT OF COST	MEAN PURCHASE COST PER SYSTEM
TOTAL, SELECTED FIELDS	46738 100%	$1630780 100%	$35
FIELD OF RESEARCH			
AGRICULTURAL SCIENCES	1954 4%	42599 3%	22
BIOLOGICAL SCIENCES, TOTAL	17619 38%	471288 29%	27
GRADUATE SCHOOLS	7290 16%	186272 11%	26
MEDICAL SCHOOLS	10329 22%	285016 17%	28
ENVIRONMENTAL SCIENCES	2679 6%	126231 8%	47
PHYSICAL SCIENCES	11644 25%	481881 30%	41
ENGINEERING	9425 20%	333613 20%	35
COMPUTER SCIENCE	1115 2%	60026 4%	54
MATERIALS SCIENCE	731 2%	37120 2%	51
INTERDISCIPLINARY, N.E.C.	1571 3%	78022 5%	50

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 8704 INSTRUMENT SYSTEMS.

TABLE A-5
DISTRIBUTION OF AGGREGATE COSTS OF ACADEMIC RESEARCH INSTRUMENT SYSTEMS IN NATIONAL STOCK, BY SYSTEM PURCHASE COST AND BY FIELD [1]

[DOLLARS IN MILLIONS]

	-AGGREGATE PURCHASE COST AND PERCENT OF COST--			
		-------SYSTEM PURCHASE COST-------		
	TOTAL	$10,000- $24,999	$25,000- $74,999	$75,000- $1,000,000
TOTAL, SELECTED FIELDS	$1630.78 100%	$463.77 28%	$520.37 32%	$646.64 40%
FIELD OF RESEARCH				
AGRICULTURAL SCIENCES	42.60 100%	23.33 55%	14.33 34%	4.94 12%
BIOLOGICAL SCIENCES, TOTAL	471.29 100%	197.29 42%	160.13 34%	113.87 24%
GRADUATE SCHOOLS	186.27 100%	81.04 44%	64.32 35%	40.91 22%
MEDICAL SCHOOLS	285.02 100%	116.25 41%	95.81 34%	72.96 26%
ENVIRONMENTAL SCIENCES	126.23 100%	22.24 18%	36.04 29%	67.95 54%
PHYSICAL SCIENCES	481.88 100%	100.21 21%	153.94 32%	227.73 47%
ENGINEERING	333.61 100%	89.46 27%	111.99 34%	132.16 40%
COMPUTER SCIENCE	60.03 100%	8.54 14%	17.53 29%	33.95 57%
MATERIALS SCIENCE	37.12 100%	5.91 16%	11.06 30%	20.15 54%
INTERDISCIPLINARY, N.E.C.	78.02 100%	16.79 22%	15.35 20%	45.88 59%

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 8704 INSTRUMENT SYSTEMS.

TABLE A-6
RESEARCH STATUS OF ACADEMIC RESEARCH INSTRUMENT SYSTEMS IN NATIONAL STOCK, BY FIELD [1]

	NUMBER AND PERCENT OF SYSTEMS				
		SYSTEM RESEARCH STATUS			
		IN RESEARCH USE		NOT YET IN RESEARCH USE	NO LONGER IN RESEARCH USE
	TOTAL	STATE-OF-THE-ART	OTHER		
TOTAL, SELECTED FIELDS	46767 100%	8075 17%	28399 61%	771 2%	9522 20%
FIELD OF RESEARCH					
AGRICULTURAL SCIENCES	1954 100%	437 22%	1215 62%	24 1%	277 14%
BIOLOGICAL SCIENCES, TOTAL	17633 100%	3268 19%	11834 67%	124 1%	2406 14%
GRADUATE SCHOOLS	7300 100%	1435 20%	4958 68%	32 -	874 12%
MEDICAL SCHOOLS	10333 100%	1833 18%	6876 67%	92 1%	1532 15%
ENVIRONMENTAL SCIENCES	2682 100%	518 19%	1608 60%	48 2%	508 19%
PHYSICAL SCIENCES	11656 100%	1725 15%	7076 61%	161 1%	2694 23%
ENGINEERING	9425 100%	1699 18%	5111 54%	327 3%	2288 24%
COMPUTER SCIENCE	1115 100%	186 17%	692 62%	65 6%	172 15%
MATERIALS SCIENCE	731 100%	116 16%	534 73%	3 -	78 11%
INTERDISCIPLINARY, N.E.C.	1571 100%	125 8%	329 21%	19 1%	1099 70%

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 8704 INSTRUMENT SYSTEMS.

TABLE A-7
AGE OF ACADEMIC RESEARCH INSTRUMENT SYSTEMS IN NATIONAL STOCK, BY FIELD [1]

	NUMBER AND PERCENT OF SYSTEMS			
		SYSTEM AGE (FROM YR OF PURCHASE)[2]		
	TOTAL	1-5 YEARS	6-10 YEARS	OVER 10 YEARS
TOTAL, SELECTED FIELDS	45890 100%	21663 47%	10885 24%	13342 29%
FIELD OF RESEARCH				
AGRICULTURAL SCIENCES	1950 100%	1028 53%	515 26%	407 21%
BIOLOGICAL SCIENCES, TOTAL	17545 100%	7768 44%	4965 28%	4812 27%
GRADUATE SCHOOLS	7250 100%	3431 47%	1854 26%	1965 27%
MEDICAL SCHOOLS	10295 100%	4337 42%	3111 30%	2847 28%
ENVIRONMENTAL SCIENCES	2664 100%	1412 53%	660 25%	592 22%
PHYSICAL SCIENCES	11484 100%	5155 45%	2461 21%	3869 34%
ENGINEERING	9224 100%	4845 53%	1723 19%	2656 29%
COMPUTER SCIENCE	1073 100%	869 81%	87 8%	116 11%
MATERIALS SCIENCE	731 100%	239 33%	113 15%	379 52%
INTERDISCIPLINARY, N.E.C.	1219 100%	346 28%	361 30%	511 42%

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 8704 INSTRUMENT SYSTEMS.

[2] FOR PHASE II FIELDS, AGE INTERVALS ARE 1-5 YEARS (1979-83); 6-10 YEARS (1974-78); OVER 10 YEARS (1973 OR BEFORE). FOR PHASE I FIELDS INTERVALS ARE 1-5 YEARS (1978-82); 6-10 YEARS (1973-77); OVER 10 YEARS (1972 OR BEFORE).

TABLE A-8
AGE OF ACADEMIC INSTRUMENT SYSTEMS IN RESEARCH USE, BY FIELD [1]

	-----NUMBER AND PERCENT OF IN-USE SYSTEMS-----			
		SYSTEM AGE (FROM YR OF PURCHASE)[2]		
	TOTAL	1-5 YEARS	6-10 YEARS	OVER 10 YEARS
TOTAL, SELECTED FIELDS	36350 100%	19419 53%	8757 24%	8174 22%
FIELD OF RESEARCH				
AGRICULTURAL SCIENCES	1653 100%	952 58%	447 27%	253 15%
BIOLOGICAL SCIENCES, TOTAL	15055 100%	7416 49%	4242 28%	3396 23%
GRADUATE SCHOOLS	6372 100%	3323 52%	1602 25%	1447 23%
MEDICAL SCHOOLS	8683 100%	4093 47%	2641 30%	1949 22%
ENVIRONMENTAL SCIENCES	2123 100%	1217 57%	546 26%	361 17%
PHYSICAL SCIENCES	8763 100%	4631 53%	1872 21%	2260 26%
ENGINEERING	6777 100%	3969 59%	1299 19%	1509 22%
COMPUTER SCIENCE	874 100%	813 93%	51 6%	10 1%
MATERIALS SCIENCE	650 100%	235 36%	103 16%	312 48%
INTERDISCIPLINARY, N.E.C.	454 100%	185 41%	196 43%	73 16%

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 6999 INSTRUMENT SYSTEMS.

[2] FOR PHASE II FIELDS, AGE INTERVALS ARE 1-5 YEARS (1979-83); 6-10 YEARS (1974-78); OVER 10 YEARS (1973 OR BEFORE). FOR PHASE I FIELDS INTERVALS ARE 1-5 YEARS (1978-82); 6-10 YEARS (1973-77); OVER 10 YEARS (1972 OR BEFORE).

TABLE A-9
PERCENT OF IN-USE RESEARCH INSTRUMENT SYSTEMS IN EXCELLENT WORKING CONDITION, BY SYSTEM RESEARCH STATUS AND BY FIELD [1]

	PERCENT OF SYSTEMS IN EXCELLENT WORKING CONDITION		
		------RESEARCH STATUS------	
	TOTAL	STATE-OF-THE-ART SYSTEMS	OTHER IN-USE SYSTEMS
TOTAL, SELECTED FIELDS	52%	84%	43%
FIELD OF RESEARCH			
AGRICULTURAL SCIENCES	56%	81%	47%
BIOLOGICAL SCIENCES, TOTAL	53%	86%	44%
GRADUATE SCHOOLS	55%	90%	44%
MEDICAL SCHOOLS	52%	82%	44%
ENVIRONMENTAL SCIENCES	50%	82%	40%
PHYSICAL SCIENCES	52%	84%	44%
ENGINEERING	51%	85%	40%
COMPUTER SCIENCE	56%	89%	47%
MATERIALS SCIENCE	32%	74%	23%
INTERDISCIPLINARY, N.E.C.	44%	58%	39%

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 6983 INSTRUMENT SYSTEMS.

TABLE A-10
RESEARCH FUNCTION OF ACADEMIC INSTRUMENTATION THAT IS USED FOR RESEARCH BUT
IS NOT STATE-OF-THE-ART, BY FIELD [1]

	NUMBER AND PERCENT OF NON STATE-OF-THE-ART SYSTEMS		
		RESEARCH FUNCTION	
	TOTAL	THE MOST ADVANCED INSTRUMENT TO WHICH ITS USERS HAVE ACCESS	USED FOR RESEARCH BUT MORE ADVANCED EQUIPMENT IS AVAILABLE WHEN NEEDED
TOTAL, SELECTED FIELDS	28335 100%	13172 46%	15163 54%
FIELD OF RESEARCH			
AGRICULTURAL SCIENCES	1215 100%	681 56%	535 44%
BIOLOGICAL SCIENCES, TOTAL	11804 100%	5076 43%	6728 57%
GRADUATE SCHOOLS	4940 100%	2158 44%	2782 56%
MEDICAL SCHOOLS	6864 100%	2918 43%	3945 57%
ENVIRONMENTAL SCIENCES	1598 100%	756 47%	841 53%
PHYSICAL SCIENCES	7067 100%	3470 49%	3598 51%
ENGINEERING	5097 100%	2536 50%	2561 50%
COMPUTER SCIENCE	692 100%	351 51%	341 49%
MATERIALS SCIENCE	534 100%	184 35%	350 65%
INTERDISCIPLINARY, N.E.C.	329 100%	118 36%	211 64%

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 5393 INSTRUMENT SYSTEMS.

TABLE A-11
SOURCES OF FUNDS FOR ACQUISITION OF IN-USE ACADEMIC RESEARCH EQUIPMENT, BY FIELD [1]

(DOLLARS IN MILLIONS)

	ACQUISITION COST AND PERCENT OF COST												
		SOURCE OF FUNDS											
		FEDERAL											
	TOTAL	TOTAL	NSF	NIH	DOD	DOE	NASA	USDA	OTHER	UNIV. FUNDS	STATE GOVT.	BUSI- NESS	OTHER
TOTAL, SELECTED FIELDS	$1178.0	$640.3	$230.8	$176.5	$103.9	$63.1	$30.8	$5.0	$30.2	$371.5	$61.5	$43.2	$61.5
	100%	54%	20%	15%	9%	5%	3%	-	3%	32%	5%	4%	5%
FIELD OF RESEARCH													
AGRICULTURAL SCIENCES	36.1	7.8	1.7	1.3	0	.3	.3	2.7	1.5	17.8	6.7	1.8	2.1
	100%	21%	5%	4%	-	1%	1%	7%	4%	49%	18%	5%	6%
BIOLOGICAL SCIENCES, TOTAL	381.3	198.5	35.3	149.7	2.1	3.5	.4	1.9	5.5	131.2	18.6	6.5	26.5
	100%	52%	9%	39%	1%	1%	-	-	1%	34%	5%	2%	7%
GRADUATE SCHOOLS	156.1	80.6	24.5	48.9	1.0	.7	.4	1.7	3.5	48.2	13.0	4.3	10.0
	100%	52%	16%	31%	1%	-	-	1%	2%	31%	8%	3%	6%
MEDICAL SCHOOLS	225.2	117.9	10.8	100.8	1.2	2.9	0	.2	2.1	83.0	5.5	2.3	16.4
	100%	52%	5%	45%	1%	1%		-	1%	37%	2%	1%	7%
ENVIRONMENTAL SCIENCES	92.3	45.7	16.5	.5	6.6	8.2	5.4	0	8.5	27.5	7.2	8.4	3.5
	100%	50%	18%	-	7%	9%	6%		9%	30%	8%	9%	4%
PHYSICAL SCIENCES	351.9	229.1	116.1	19.5	32.3	33.0	22.3	.1	5.7	92.2	6.6	4.1	20.0
	100%	65%	33%	6%	9%	9%	6%	-	2%	26%	2%	1%	6%
ENGINEERING	218.9	106.4	35.1	2.7	45.8	14.4	2.2	.3	5.8	78.5	13.5	13.1	7.4
	100%	49%	16%	1%	21%	7%	1%	-	3%	36%	6%	6%	3%
COMPUTER SCIENCE	46.9	21.5	10.8	.3	9.1	.3	0	0	1.0	11.5	4.9	7.7	1.2
	100%	46%	23%	1%	19%	1%	-		2%	25%	10%	16%	3%
MATERIALS SCIENCE	34.1	24.3	13.5	.7	5.4	3.4	0	0	1.3	6.0	2.6	.6	.6
	100%	71%	40%	2%	16%	10%			4%	18%	8%	2%	2%
INTERDISCIPLINARY, N.E.C.	16.6	7.0	1.8	1.9	2.4	0	0	0	.9	6.8	1.5	.9	.4
	100%	42%	11%	11%	15%	-	-	-	5%	41%	9%	6%	2%

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 6985 INSTRUMENT SYSTEMS.

TABLE A-12
FIELDS RECEIVING FUNDING SUPPORT FOR ACQUISITION OF IN-USE RESEARCH EQUIPMENT, BY SOURCE OF FUNDS [1]

(DOLLARS IN MILLIONS)

	ACQUISITION COST AND PERCENT OF COST												
		SOURCE OF FUNDS											
		FEDERAL											
	TOTAL	TOTAL	NSF	NIH	DOD	DOE	NASA	USDA	OTHER	UNIV. FUNDS	STATE GOVT.	BUSI-NESS	OTHER
TOTAL, SELECTED FIELDS	$1178.0 100%	$640.3 100%	$230.8 100%	$176.5 100%	$103.9 100%	$63.1 100%	$30.8 100%	$5.0 100%	$30.2 100%	$371.5 100%	$61.5 100%	$43.2 100%	$61.5 100%
FIELD OF RESEARCH													
AGRICULTURAL SCIENCES	36.1 3%	7.8 1%	1.7 1%	1.3 1%	0 -	.3 -	.3 1%	2.7 54%	1.5 5%	17.8 5%	6.7 11%	1.8 4%	2.1 3%
BIOLOGICAL SCIENCES, TOTAL	391.3 32%	198.5 31%	35.3 15%	149.7 85%	2.1 2%	3.5 6%	.4 1%	1.9 37%	5.5 18%	131.2 35%	18.6 30%	6.5 15%	26.5 43%
GRADUATE SCHOOLS	166.1 13%	80.6 13%	24.5 11%	48.9 28%	1.0 1%	.7 1%	.4 1%	1.7 34%	3.5 11%	48.2 13%	13.0 21%	4.3 10%	10.0 16%
MEDICAL SCHOOLS	225.2 19%	117.9 18%	10.8 5%	100.8 57%	1.2 1%	2.9 5%	0	.2 3%	2.1 7%	83.0 22%	5.5 9%	2.3 5%	16.4 27%
ENVIRONMENTAL SCIENCES	92.3 8%	45.7 7%	16.5 7%	.5 -	6.6 6%	8.2 13%	5.4 18%	0	8.5 28%	27.5 7%	7.2 12%	8.4 19%	3.5 6%
PHYSICAL SCIENCES	351.9 30%	229.1 36%	116.1 50%	19.5 11%	32.3 31%	33.0 52%	22.3 73%	.1 2%	5.7 19%	92.2 25%	6.6 11%	4.1 10%	20.0 32%
ENGINEERING	216.9 19%	106.4 17%	35.1 15%	2.7 2%	45.8 44%	14.4 23%	2.2 7%	.3 7%	5.8 19%	78.5 21%	13.5 22%	13.1 30%	7.4 12%
COMPUTER SCIENCE	46.9 4%	21.5 3%	10.8 5%	.3 -	9.1 9%	.3 -	0 -	0	1.0 3%	11.5 3%	4.9 8%	7.7 18%	1.2 2%
MATERIALS SCIENCE	34.1 3%	24.3 4%	13.5 6%	.7 -	5.4 5%	3.4 5%	0	0	1.3 4%	6.0 2%	2.6 4%	.6 1%	.6 1%
INTERDISCIPLINARY, N.E.C.	16.6 1%	7.0 1%	1.8 1%	1.9 1%	2.4 2%	0 -	0 -	0 -	.9 3%	6.8 2%	1.5 2%	.9 2%	.4 1%

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 6985 INSTRUMENT SYSTEMS.

TABLE A-13

FEDERAL INVOLVEMENT IN FUNDING OF IN-USE ACADEMIC RESEARCH INSTRUMENT SYSTEMS, BY FIELD [1]

	PERCENT OF SYSTEMS			
		FEDERAL FUNDING INVOLVEMENT		
	TOTAL	NO FUNDING	PARTIAL FUNDING	100% FUNDING
TOTAL, SELECTED FIELDS	100%	38%	18%	44%
FIELD OF RESEARCH				
AGRICULTURAL SCIENCES	100%	72%	10%	18%
BIOLOGICAL SCIENCES, TOTAL	100%	40%	12%	49%
GRADUATE SCHOOLS	100%	41%	14%	45%
MEDICAL SCHOOLS	100%	39%	10%	51%
ENVIRONMENTAL SCIENCES	100%	43%	18%	38%
PHYSICAL SCIENCES	100%	24%	27%	49%
ENGINEERING	100%	43%	20%	37%
COMPUTER SCIENCE	100%	42%	29%	29%
MATERIALS SCIENCE	100%	13%	32%	55%
INTERDISCIPLINARY, N.E.C.	100%	50%	27%	23%

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 6909 INSTRUMENT SYSTEMS.

TABLE A-14
LOCATION OF IN-USE ACADEMIC RESEARCH INSTRUMENT SYSTEMS, BY FIELD [1]

	NUMBER AND PERCENT OF SYSTEMS					
		LOCATION				
	TOTAL	LAB OF INDIVIDUAL P.I.	NAT'L OR REGIONAL LAB	NONDEPART-MENTAL FACILITY	DEPARTMENT MANAGED COMMON LAB	OTHER SHARED ACCESS
TOTAL, SELECTED FIELDS	36212	21390	484	2340	11466	532
	100%	59%	1%	6%	32%	1%
FIELD OF RESEARCH						
AGRICULTURAL SCIENCES	1631	1037	12	61	504	18
	100%	64%	1%	4%	31%	1%
BIOLOGICAL SCIENCES, TOTAL	15016	9739	108	483	4641	45
	100%	65%	1%	3%	31%	-
GRADUATE SCHOOLS	6353	4168	62	223	1871	29
	100%	66%	1%	4%	29%	-
MEDICAL SCHOOLS	8663	5571	46	260	2770	16
	100%	64%	1%	3%	32%	-
ENVIRONMENTAL SCIENCES	2083	1080	56	280	580	88
	100%	52%	3%	13%	28%	4%
PHYSICAL SCIENCES	8731	5708	196	546	2118	163
	100%	65%	2%	6%	24%	2%
ENGINEERING	6777	3412	56	430	2673	205
	100%	50%	1%	6%	39%	3%
COMPUTER SCIENCE	878	170	2	122	573	11
	100%	19%	-	14%	65%	1%
MATERIALS SCIENCE	642	121	37	309	176	0
	100%	19%	6%	48%	27%	-
INTERDISCIPLINARY, N.E.C.	454	124	17	109	203	2
	100%	27%	4%	24%	45%	-

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 6985 INSTRUMENT SYSTEMS.

TABLE A-15
RESEARCH FUNCTION OF IN-USE ACADEMIC RESEARCH INSTRUMENT SYSTEMS, BY FIELD [1]

	NUMBER AND PERCENT OF SYSTEMS			
		RESEARCH FUNCTION		
		DEDICATED		
	TOTAL	MODIFIED	NOT MODIFIED	GENERAL PURPOSE
TOTAL, SELECTED FIELDS	35768 100%	2321 6%	7432 21%	26014 73%
FIELD OF RESEARCH				
AGRICULTURAL SCIENCES	1602 100%	64 4%	316 20%	1222 76%
BIOLOGICAL SCIENCES, TOTAL	14760 100%	660 4%	1835 12%	12265 83%
GRADUATE SCHOOLS	6212 100%	226 4%	652 11%	5334 86%
MEDICAL SCHOOLS	8548 100%	434 5%	1183 14%	6931 81%
ENVIRONMENTAL SCIENCES	2103 100%	189 9%	499 24%	1414 67%
PHYSICAL SCIENCES	8630 100%	771 9%	2604 30%	5255 61%
ENGINEERING	6724 100%	582 9%	1896 28%	4246 63%
COMPUTER SCIENCE	866 100%	4 -	140 16%	722 83%
MATERIALS SCIENCE	637 100%	36 6%	95 15%	506 79%
INTERDISCIPLINARY, N.E.C.	445 100%	16 4%	46 10%	383 86%

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 6985 INSTRUMENT SYSTEMS.

TABLE A-16
MEAN NUMBER OF RESEARCH USERS OF IN-USE ACADEMIC RESEARCH INSTRUMENT SYSTEMS, BY RESEARCH FUNCTION AND BY FIELD [1]

	MEAN NUMBER OF RESEARCH USERS [2]			
		RESEARCH FUNCTION		
		DEDICATED		
	TOTAL	MODIFIED	NOT MODIFIED	GENERAL PURPOSE
TOTAL, SELECTED FIELDS	14.3	7.5	8.4	16.6
FIELD OF RESEARCH				
AGRICULTURAL SCIENCES	11.0	8.1	6.6	12.0
BIOLOGICAL SCIENCES, TOTAL	11.5	7.9	6.6	12.4
GRADUATE SCHOOLS	12.4	11.0	6.5	13.1
MEDICAL SCHOOLS	10.8	6.3	6.7	11.9
ENVIRONMENTAL SCIENCES	12.4	7.7	6.1	15.3
PHYSICAL SCIENCES	15.5	6.5	8.0	20.6
ENGINEERING	14.1	6.3	10.8	16.8
COMPUTER SCIENCE	32.6	32.6	20.2	38.5
MATERIALS SCIENCE	24.5	27.0	6.8	27.5
INTERDISCIPLINARY, N.E.C.	15.0	19.3	16.8	14.8

[1] ALL STATISTICS ARE NATIONAL ESTIMATES ENCOMPASSING THE 157 LARGEST R & D UNIVERSITIES AND THE 92 LARGEST R & D MEDICAL SCHOOLS IN THE NATION. FOR PHASE II FIELDS (AGRICULTURAL, BIOLOGICAL AND ENVIRONMENTAL SCIENCES), ESTIMATES ARE AS OF DECEMBER 1983. FOR ALL OTHER FIELDS, ESTIMATES ARE AS OF DECEMBER 1982. SAMPLE IS 6985 INSTRUMENT SYSTEMS.

[2] FOR PHASE II FIELDS, ESTIMATES ARE OF USERS DURING 1983; FOR PHASE I FIELDS, ESTIMATES ARE OF USERS DURING 1982.

APPENDIX B

DEPARTMENT/FACILITY QUESTIONNAIRE

Form Number

OMB No. 3145-0067
Expiration Date 9/30/85

NATIONAL SCIENCE FOUNDATION
DIVISION OF SCIENCE RESOURCES STUDIES

NATIONAL SURVEY OF ACADEMIC RESEARCH INSTRUMENTS AND INSTRUMENTATION NEEDS

DEPARTMENT/FACILITY QUESTIONNAIRE

THIS REPORT IS AUTHORIZED BY LAW (P.L. 96-44). WHILE YOU ARE NOT REQUIRED TO RESPOND, YOUR COOPERATION IS NEEDED TO MAKE THE RESULTS OF THIS SURVEY COMPREHENSIVE, ACCURATE, AND TIMELY. INFORMATION GATHERED IN THIS SURVEY WILL BE USED ONLY FOR DEVELOPING STATISTICAL SUMMARIES. INDIVIDUAL PERSONS, INSTITUTIONS, AND DEPARTMENTS WILL NOT BE IDENTIFIED IN PUBLISHED SUMMARIES OF THE DATA.

BACKGROUND AND INSTRUCTIONS

In recent years, widespread concern has developed about whether university research scientists and engineers have sufficient access to the kinds of equipment needed to permit continuing research at the frontier of scientific knowledge. To assist the National Science Foundation and other Federal agencies in setting appropriate equipment funding levels and priorities, this Congressionally mandated survey is intended to document, for the first time: (a) the amount, cost, and condition of the scientific research equipment currently available in the nation's principal research universities, and (b) the nature and extent of the need for upgraded or expanded equipment in the major fields of science and engineering.

The survey is being conducted in two phases. The current phase deals with research equipment in the physical sciences and engineering/computer science. Next year, in Phase II, the emphasis will be on the biological, environmental, and agricultural sciences.

This Department (or nondepartmental research facility) Questionnaire seeks a broad overview of equipment-related expenditures and needs in this department (or facility). Items 1-10 (Parts A and B) are factual in nature and may be delegated to any person or persons who can provide the requested data. In these sections, informed estimates are acceptable whenever precise information is not available from annual reports or other data sources. Items 11-16 (Part C) call for judgmental assessments about equipment-related research needs and priorities of the department (or facility) as a whole and should be answered by the department chairperson (or facility director) or by a designee who is in a position to make such judgments. We urge that particular attention be given to item 16, which asks for this department's (or facility's) recommendations about needed changes in equipment funding policies and procedures.

This form should be returned by May 30, 1983. Your cooperation in returning the survey form promptly is very important. Please direct any questions about this form either to your university study coordinator or to Ms. Dianne Walsh at Westat, Inc., the NSF contractor for this study (301-251-1500).

PART A. DESCRIPTIVE INFORMATION

1. Institution name: ______________________________

2. Department (or nondepartmental research facility) name:

____

3. This is a: (CHECK ONE)

   ☐ 1. Department (CONTINUE WITH ITEM 4)
   ☐ 2. Nondepartmental research facility (SKIP TO ITEM 6)

4. Number of doctoral degrees awarded in 1981-82 academic year to students in this department:

   ____

5. Number of members of this department who participate in ongoing research projects (do not include graduate students or postdoctorates):

   ________ Total number of persons (full-time and part-time)
   ________ FTE* number of persons

PART B. RESEARCH-RELATED FUNDING AND EXPENDITURES

6. Department (or facility) FY 1982 and anticipated FY 1983 expenditures for scientific research equipment. [SCIENTIFIC RESEARCH EQUIPMENT IS ANY ITEM (OR INTERRELATED COLLECTION OF ITEMS COMPRISING A SYSTEM) OF NONEXPENDABLE TANGIBLE PROPERTY OR SOFTWARE HAVING A USEFUL LIFE OF MORE THAN TWO YEARS AND AN ACQUISITION COST OF $500 OR MORE WHICH IS USED WHOLLY OR IN PART FOR RESEARCH. INCLUDE ALL SCIENTIFIC RESEARCH EQUIPMENT ACQUIRED IN THIS DEPARTMENT (OR FACILITY) IN FY 1982, FROM ALL SOURCES -- FEDERAL, STATE, INSTITUTIONAL, INDUSTRIAL, ETC.]

   $____________ FY 1982 expenditures for scientific research equipment
   $____________ Anticipated FY 1983 expenditures for scientific research equipment

---

*In computing number of FTEs (full-time equivalents), persons employed in this department on less than a full-time basis should be counted to reflect their decimal fraction of full-time equivalency. Example: if a department employs 25 pertinent faculty members, 20 full-time and 5 with half-time appointments, the FTE number is 20 + (5 x .5) = 22.5.

7. Please provide an approximate breakdown by source of funds for this department's (or facility's) FY 1982 expenditures and estimated FY 1983 expenditures for scientific research equipment. [NOTE: ENTRIES IN EACH COLUMN SHOULD SUM TO 100 PERCENT; ESTIMATES ARE ACCEPTABLE.]

Source of funds	Percent of expenditures for scientific research equipment	
	FY 1982	FY 1983 (anticipated)
a. Federal government	________%	________%
b. Internal university funds	________%	________%
c. State equipment or capital development appropriations	________%	________%
d. Private nonprofit foundations/organizations	________%	________%
e. Business or industry	________%	________%
f. Other (SPECIFY) ________		
________	________%	________%
TOTAL, ALL FUNDING SOURCES	100 %	100 %

8. FY 1982 expenditures for purchase of research-related computer services at:

$________ On-campus computing facilities

$________ Off-campus computing facilities

9. FY 1982 expenditures for maintenance and repair of all scientific research equipment in this department (or facility):

$________ Service contracts or field service for maintenance and repair of individual instruments

$________ Salaries of university maintenance/repair personnel (prorate if personnel do not work full-time in this department/facility or on servicing of research equipment)

$________ Other direct costs of supplies, equipment and facilities for servicing of research instruments in this department/facility

$________ Total

10. Are the instrumentation support services (e.g., machine shop, electronics shops) at this department or facility: (CHECK ONE)

☐ 1. Excellent
☐ 2. Adequate
☐ 3. Insufficient
☐ 4. Nonexistant

PART C. ADEQUACY OF AND NEED FOR SCIENTIFIC RESEARCH EQUIPMENT

11. In terms of its capability to enable investigators to pursue their major research interests, is the research equipment in this department (or facility) generally: (CHECK ONE IN EACH COLUMN)

	Type of investigator	
	Tenured faculty (and equivalent P.I.'s)	Untenured faculty (and equivalent P.I.'s)
1. Excellent	1. ☐	1. ☐
2. Adequate	2. ☐	2. ☐
3. Insufficient	3. ☐	3. ☐

12. Are there any important subject areas (e.g., recombitant DNA, microcircuitry, plasma physics) in which investigators in this department/facility are unable to perform critical experiments in their areas of research interest due to lack of needed equipment?

☐ 1. Yes ——→ 12a. What are the top priority subject areas for expansion/upgrading of presently available equipment? (SPECIFY UP TO THREE AREAS)

____

____

☐ 2. No

____

13. Assuming future total Federal research support to your department/facility remains roughly constant at present levels, how - if at all - would your department (or facility) redistribute its research funds. FOR EACH AREA, PLEASE INDICATE WHETHER FUNDING SHOULD BE PROPORTIONATELY INCREASED, DECREASED, OR MAINTAINED AT ABOUT THE PRESENT LEVEL. (NOTE: PROPORTIONATE INCREASES IN ONE OR MORE AREAS MUST BE ACCOMPANIED BY CORRESPONDING DECREASES IN OTHER AREAS. IF THE CURRENT BALANCE SHOULD BE MAINTAINED, CHECK "NO CHANGE" COLUMN FOR ALL AREAS.)

Area of Federal support	Recommended redistribution of research funds		
	1. Increase	2. Decrease	3. No change
a. Faculty salaries	☐	☐	☐
b. Postdoctorate salaries	☐	☐	☐
c. Graduate student support	☐	☐	☐
d. Non-professional salaries	☐	☐	☐
e. Equipping of startup labs	☐	☐	☐
f. Equipment purchases (other than e, above)	☐	☐	☐
g. Equipment maintenance	☐	☐	☐
h. Other (SPECIFY) ________ ____________________	☐	☐	☐

14. If greater Federal funding of research equipment were possible, in which area would increased investment be most beneficial to investigators in this department/facility? (CHECK ONE)

☐ 1. Large scale regional and national facilities (large telescopes, reactors, oceanographic vessels, high performance computers, etc.)

☐ 2. Major shared access instrument systems ($50,000-$1,000,000) not presently available to department/facility members

☐ 3. Upgrading/expansion of equipment in $10,000-$50,000 range

☐ 4. General enhancement of equipment and supplies in labs of individual P.I.'s (items generally below $10,000)

☐ 5. Other (SPECIFY) ______________________

15. In the $10,000-$1,000,000 cost range, what three items of research equipment (if any) are most needed at this time in this department/facility?

Item description	Approximate cost

16. How could current Federal equipment funding policies and/or procedures be modified to better meet the research needs of researchers in this department/facility?

17. Please note in the space below: (a) any additional information needed to describe the research equipment and equipment-related needs in this department/facility, or (b) any suggestions to improve this survey questionnaire.

18. Person who prepared this submission:

NAME AND TITLE

AREA CODE - EXCH - NO. - EXT.

19. How many person-hours were required to complete this form? ______ HOURS ______ MINUTES

APPENDIX C

INSTRUMENT DATA SHEET

Form
Number:

OMB No. 3145-0067
Expiration Date 9/30/85

NATIONAL SURVEY OF ACADEMIC RESEARCH INSTRUMENTS AND INSTRUMENTATION NEEDS

NATIONAL SCIENCE FOUNDATION AND NATIONAL INSTITUTES OF HEALTH

INSTRUMENT DATA SHEET

This data sheet is part of a major national assessment of the condition of academic research instrumentation. The data sheet concerns a particular instrument or instrument system component selected from university central inventory records as part of a national sample of research instruments in your field.

The item described below (in ID BOX) is assumed to be an instrument or instrument system component: (a) assigned to this department or research facility and (b) used in 1983 for original scientific research—as distinguished from teaching, patient care or other nonresearch uses, or from inactive or inoperable equipment not used at all in 1983. Please note in the comments section (Question 17) if either assumption is incorrect; however, please complete as much of this form as possible.

We ask that the requested factual information (items 1-8) and functional assessment data (items 9-16) be obtained from the person or persons who are most knowledgeable about the history and current status of this instrument. Where exact cost (or other) data are not available, estimates are acceptable. Your estimates will be better than ours.

This study is authorized by law (P.L. 98-44). While you are not required to respond, your cooperation is needed to make the results of this survey comprehensive, accurate, and timely. Information gathered in this survey will be used only for developing statistical summaries. Individual persons, institutions, and departments will not be identified in published summaries of the data.

Your cooperation in returning the survey form promptly is very important. Please direct any questions about this form either to your university study coordinator or to Ms. Dianne Walsh at Westat, Inc., the NSF/NIH contractor for this study (301-251-1500).

DEFINITION OF KEY TERMS

INSTRUMENT PURCHASE PRICE (initial value)

The original price of the instrument (or its components, if built locally) at time of original purchase from the manufacturer. Do not include cost of separately purchased accessories; do not subtract any discount (e.g., for trade-in) which may have been received. Please estimate if original records are not available.

ACQUISITION COST

The actual cost of this instrument when acquired at this institution. If purchased new by this university, acquisition cost = purchase price, less discount from manufacturer, if applicable. If built at this institution, acquisition cost = cost of parts + estimated cost of labor. If purchased used, acquisition cost = price paid to seller. If donated or loaned (e.g., by industry) or obtained at no cost from government surplus, acquisition cost = $0.

REPLACEMENT COST

The estimated cost to purchase this instrument (or its components, if built locally) or one of roughly equivalent function and capability, at today's prices.

DEDICATED ACCESSORIES

Separately acquired "add-ons" to or components of the instrumentation system of which the instrument described below is the principal element. This includes accessories that are presently dedicated solely for use with the reference instrument but are not included in its purchase cost (in item G, below). Examples: specimen preparation and photographic accessories for a particular electron microscope; oscilloscope, microprocessor, HPLC, or data system accessories for a particular spectrometer; key entry, disc drive, printer or plotter accessories for a particular microcomputer.

YEAR OF PURCHASE

The calendar year when this instrument (or its principal components) was originally purchased from the manufacturer.

ID BOX - INSTRUMENT IDENTIFYING DATA

A. Institution ____________________

B. Department or Facility ____________________

C. Instrument Description ____________________

D. Central Records ID # ____________________

E. Location: ____________________

F. Year of Purchase: 19________ G. Instrument Purchase Price:

1. Please review the identifying data (from your institution's central inventory records) in the page 1 ID BOX and make any needed corrections or additions, with special attention to items F (**YEAR OF PURCHASE**) and G (**INSTRUMENT PURCHASE PRICE**).

SEE PAGE 1 FOR DEFINITION OF ALL BOLDFACE TERMS

2. Where was this instrument located during 1983 when in use? (CHECK ONE)

☐ 1 Inactive or inoperable throughout 1983 (SKIP TO ITEM 17)

☐ 2 Lab or facility used almost exclusively for undergraduate instruction or other nonresearch activity (SKIP TO ITEM 17)

☐ 3 National, regional, or interuniversity research instrumentation lab (CONTINUE TO ITEM 3)

☐ 4 Nondepartmental research facility (CONTINUE TO ITEM 3)

☐ 5 Department-managed common lab or research instrumentation facility (CONTINUE TO ITEM 3)

☐ 6 Within-department research lab of principal investigator (CONTINUE TO ITEM 3)

☐ 7 Other (SPECIFY) ______________________________

3. Does this instrument have any **DEDICATED ACCESSORIES** not included in the **INSTRUMENT PURCHASE PRICE** (from ID BOX, item G)? (See page 1 definitions of key terms)

☐ 1 Yes ⟶ 3a. Estimated aggregate purchase price of all **DEDICATED ACCESSORIES** not included in ID BOX item G. $__________

☐ 2 No

3b. Please describe and estimate the purchase price for each separately purchased **DEDICATED ACCESSORY** costing $10,000 or more. (If additional space is needed, continue in Question 17 or attach a separate continuation sheet.)

Description of accessories $10,000 or more	Purchase cost
1. ______________________	$__________
2. ______________________	$__________
3. ______________________	$__________
4. ______________________	$__________

4. Year instrument acquired at this institution:

19 ______

5. **ACQUISITION COST** for this instrument and its accessories (see page 1 definition):

$__________ Instrument acquisition cost

$__________ Accessory acquisition cost

$__________ Total

6. Estimated **REPLACEMENT COST** for this instrument and its accessories (see page 1 definition):

$__________ Instrument replacement cost

$__________ Accessory replacement cost

$__________ Total

7. How was this instrument acquired at this institution? (CHECK ONE)

☐ 1 Purchased new
☐ 2 Purchased used
☐ 3 Locally built (at or for this institution)
☐ 4 Transferred from another institution, e.g., by incoming faculty member (SKIP TO ITEM 9)
☐ 5 Government surplus (SKIP TO ITEM 9)
☐ 6 Donated new (SKIP TO ITEM 9)
☐ 7 Donated used (SKIP TO ITEM 9)
☐ 8 Other (SPECIFY) ____________________

____

8. Source(s) of funds for acquisition of this instrument (and accessories) at this institution. (SPECIFY APPROXIMATE PERCENTAGE CONTRIBUTION TO TOTAL ACQUISITION COST FOR EACH APPLICABLE SOURCE.)

Funding contribution (percent)	Funding source
	Federal sources:
________	NSF (National Science Foundation)
________	NIH (National Institutes of Health)
________	DOD (Department of Defense)
________	DOE (Department of Energy)
________	USDA (Department of Agriculture)
________	Other Federal sources (SPECIFY): ____________________
	Non-Federal sources:
________	Institution or department funds
________	State grant or appropriation
________	Private nonprofit foundation
________	Business or industry
________	Other (SPECIFY) ____________________
100%	Total

9. How much was spent for maintenance and repair (not for operation) of this instrument and its accessories in 1983?

$__________

10. Means of servicing (maintenance/repair) this instrument during 1983: (CHECK ALL THAT APPLY)

☐ 1 None required
☐ 2 Service contract
☐ 3 Field service, as needed
☐ 4 Institution-employed maintenance/repair staff
☐ 5 Research personnel (faculty, students, post-docs)
☐ 6 Other (SPECIFY) ____________________

11. Instrument's general working condition during 1983: (CHECK ONE)

☐ 1 Excellent
☐ 2 Average
☐ 3 Poor (e.g., unreliable, frequent breakdowns, difficult to maintain or service)
☐ 4 Inoperable entire year

12. Research function of this instrument during 1983: (CHECK ONE)

☐ 1 Most advanced instrument of its kind that is accessible to those who use it in their research
☐ 2 Used for research; more advanced instruments are available to users when needed
☐ 3 Not used for research during 1983

13. Technical capabilities of this instrument (i.e., the base instrument, excluding accessories) (CHECK ONE)

☐ 1 State-of-the-art (most highly developed and scientifically sophisticated instrument available)
☐ 2 Adequate to meet researcher needs
☐ 3 Inadequate for research (PLEASE EXPLAIN):

____

____

____

14. Technical capabilities of instrument's current accessories. (CHECK ONE)

☐ 1 Not applicable - Instrument does not have accessories

☐ 2 State-of-the-art (most highly developed and scientifically sophisticated available)

☐ 3 Adequate to meet researcher needs

☐ 4 Inadequate for research (PLEASE EXPLAIN)

____

____

____

15. In 1983, was this a general purpose instrument within an area of research or was it dedicated for a particular experiment or series of experiments? (CHECK ONE)

☐ 1 General purpose (SKIP TO ITEM 16)

☐ 2 Dedicated

15a. Did this involve any special calibration, programming or other modifications which rendered the instrument unsuitable for general purpose use? (CHECK ONE)

☐ 1 Yes

☐ 2 No

16. How many research investigators made use of this instrument for research purposes during 1983? (ESTIMATE APPROXIMATE NUMBER IN EACH APPLICABLE CATEGORY)

______ 1 Faculty and equivalent nonfaculty researchers, this department/facility

______ 2 Graduate and medical students and postdoctorates, this department/facility

______ 3 Faculty and equivalent nonfaculty researchers, other departments, this university

______ 4 Graduate and medical students and postdoctorates, other departments, this university

______ 5 Researchers from other universities

______ 6 Nonacademic researchers

______ 7 Other (SPECIFY) ______________________________

______ Total number of research users

16a. Instrument's principal field of research use in 1983 (e.g., geology, biophysics, plant pathology, pharmacology):

____

17. Please note in space below: (a) Any additional information needed to clarify the nature, function and quality of this instrument, or (b) any suggestions to improve this questionnaire or its instructions.

18. Person who prepared this submission:

______________________________ ____________________
NAME AND TITLE AREA CODE - EXCH - NO - EXT

19. How many person-hours were required to complete this form? __________ __________
HOURS MINUTES

APPENDIX D

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